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Dear readers,

This issue contains articles about the development of prices on the Swedish housing market, the effects of various measures to reduce household indebtedness and challenges faced and considerations made by central banks when they lend money to the financial system.

- **Is a bubble forming in Swedish housing prices?**

  Emilio Dermani, Jesper Lindé and Karl Walentin analyse the development of prices for single-family dwellings in Sweden 1990–2015 from an international perspective. They find that several fundamental factors acting together may explain the rise in prices experienced across the country as a whole. Compared with other countries in the study, Sweden has had a greater increase in disposable incomes and financial net wealth but also, at the same time, a lower level of residential investment. Together with the rapid rate of population growth and the exceptionally low nominal and real interest rates of recent years, this has contributed towards the strong increase of housing prices in Sweden.

  They also study the development of prices on the municipal level, focusing on municipalities in which households have unusually high housing expenditure in relation to income. They find that this phenomenon is primarily found in metropolitan areas and that the inhabitants of these municipalities have, for a long time, spent a larger proportion of their incomes on housing than have inhabitants in the average municipality.

  Even though their analysis does not support the hypothesis that the market for single-family dwellings is necessarily overvalued, the authors consider that the rising prices may be unsustainable in the long term. For example, a powerful and sustained rise in the real interest rate would lead to the risk of a rapid fall in housing prices. There are thus good reasons to halt the rise in household indebtedness using various types of policies.

- **What are the macroeconomic effects of reducing household debt?**

  Daria Finocchiaro, Magnus Jonsson, Christian Nilsson and Ingvar Strid study, using a macroeconomic model, how different households would be affected by more stringent macroprudential policy measures or tighter mortgage interest deduction. They show that stricter requirements for loan-to-value limits, debt-to-income limits and amortisations will lead, in the longer term, to a reallocation of resources from lenders to borrowers.

They also show that tighter mortgage interest deduction affects households differently depending on how the government spends the budget funds made available. If the borrowers are compensated for the reduced tax relief on mortgages, such a measure can be positive for their consumption other than housing.

How monetary policy is affected depends on the type of measure implemented; in some cases monetary policy may need to become more expansionary, and in others tighter.

The article concludes with an analysis of how household indebtedness affects the impact of monetary policy on demand and inflation. The higher indebtedness is, the greater effect an interest rate rise will have on borrowers' interest expenditures and disposable incomes, which, in turn, will give households less scope for other consumption. The effects of an interest rate rise on demand – and thus on inflation – is therefore greater today than when inflation targeting was introduced in the mid-1990s.

- **The central bank's task of providing liquidity to the financial system – what are the challenges?**

  Christoph Bertsch and Johan Molin review the central bank's role as a provider of liquidity to the financial system.

  The authors start by analysing the provision of liquidity by central banks using economic theory and historical examples. They go on to present the various tools that today's central banks can use to supply liquidity in various situations.

  The authors then analyse, in depth, the special challenges and considerations facing central banks when they choose their tools and determine the conditions for their use.

  They discuss, among other matters, how these challenges and considerations have been affected by the global financial crisis. Special attention is given to potential obstacles to the effectiveness of central bank liquidity provision and implications for market discipline and risk-taking in financial markets.

  Finally, Bertsch and Molin discuss how structural changes in the financial system, new regulations and technological innovations in the area of finance may affect the conditions for the central banks' liquidity support in the future.

Read and enjoy!

Claes Berg

Contents

Is there an evident housing bubble in Sweden?

Emilio Dermani, Jesper Lindé and Karl Walentin*
The authors work in the Research Division of the Riksbank.

A discussion has been ongoing for some time on house prices and household indebtedness in Sweden, and whether their current levels are sustainable in the long term. In this article we study this issue for single-family house prices, both in Sweden as a whole and in various municipalities. Our results do not support the notion that Swedish houses are evidently overvalued in the country as a whole, if we assume that their prices are influenced by the relevant economic variables in the same way as in a number of other countries. When we change our perspective and look at how house prices on the municipal level have developed relative to earned income in the same municipalities, we cannot find any strong evidence for abnormal price differences among municipalities. However, the current high valuations of housing is only sustainable in the long term if households' housing costs remain low in relation to their income. Concern over the current developments on the Swedish housing market is therefore justified.

1 Introduction

Many macroeconomic analysts have recently expressed considerable concern regarding how the Swedish housing market is developing, with sharply rising house prices.[1]

In the wake of rising house prices, the indebtedness of the Swedish households has also increased sharply. As a percentage of disposable income,

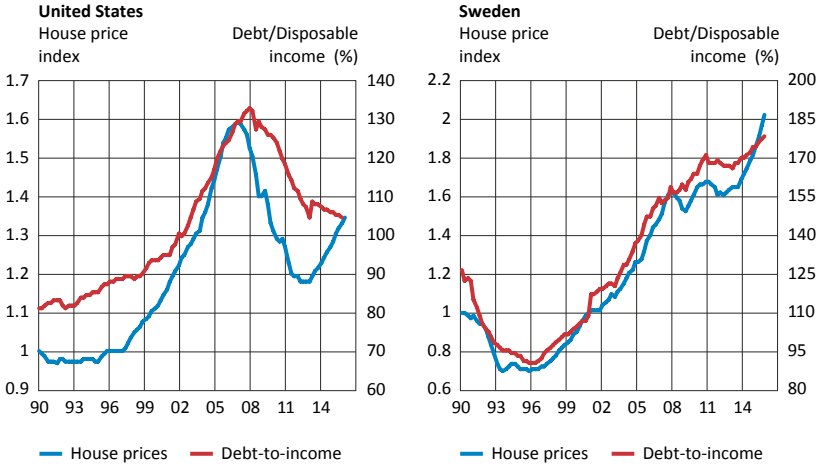
* The authors have had valuable discussions with Martin Flodén and Paolo Giordani on the subject, but not specifically on the article. We would also like to thank Claes Berg, Carl Andreas Claussen, Robert Emanuelsson and Dilan Ölcer, as well as the participants of the AFS Forum for their valuable comments. A special big thank-you to Gary Watson for translating the article from Swedish to English, and Jessica Radeschnig and Caroline Richards for valuable language improvements on the Swedish version. We are, however, ourselves responsible for any inaccuracies. The opinions expressed in this article are the sole responsibility of the authors and should not be interpreted as reflecting the views of Sveriges Riksbank.

1 See for example European Commission (2016), Giordani et al. (2015), KI (2015) and Birch Sørensen (2013, for the Swedish Fiscal Policy Council), for a discussion of Swedish house prices.

household indebtedness has doubled since 1995 and now stands at about 180 per cent. House prices have also doubled in real terms since 1995. The development of both house prices and indebtedness is documented in detail in Figure 1, for both Sweden and the United States.[2]

There may be a variety of reasons why analysts are concerned about this development. One of them is that the current situation in Sweden is reminiscent of the development in the United States before house prices crashed there, with record-high and rapidly rising house prices and indebtedness levels. Another is Sweden's experience from the crisis in the 1990s, when a sharp house price fall coincided with a very deep recession and serious banking crisis.

Figure 1. House prices and household indebtedness in the United States and Sweden



Note. House prices are in real terms (i.e. deflated by the CPI), seasonally adjusted and normalised to 1 in the first quarter of 1990. The debt-to-income ratio refers to total household debt in relation to disposable income.
Sources: House price index: Dallas FED. Debt/disposable income: FRED database

Note. House prices are in real terms (i.e. deflated by the CPIF), seasonally adjusted and normalised to 1 in the first quarter of 1990. The debt-to-income ratio refers to total household debt in relation to disposable income.
Sources: House price index: Dallas FED. Debt/disposable income: The Riksbank

As can be seen in Figure 1, house prices fell at the beginning of the 1990s by around 35 per cent in real terms, while in the US they fell by about 25 per cent during the most recent financial crisis, i.e. by slightly less than in Sweden. Swedish households also reduced their debt as a percentage of disposable income (debt-

2 The economic issue we discuss in this article concerns house prices in general, i.e. prices of both houses and tenant-owned apartments. In practice, however, we will work exclusively with data for houses (single-family dwellings) as the series are available for longer time periods.

to-income ratio) by just over 30 percentage points by the end of 1995, while the debt-to-income ratio in the US has fallen by around 25 percentage points since 2007 up until the present. There are hence major similarities between Swedish and US developments during both crises.

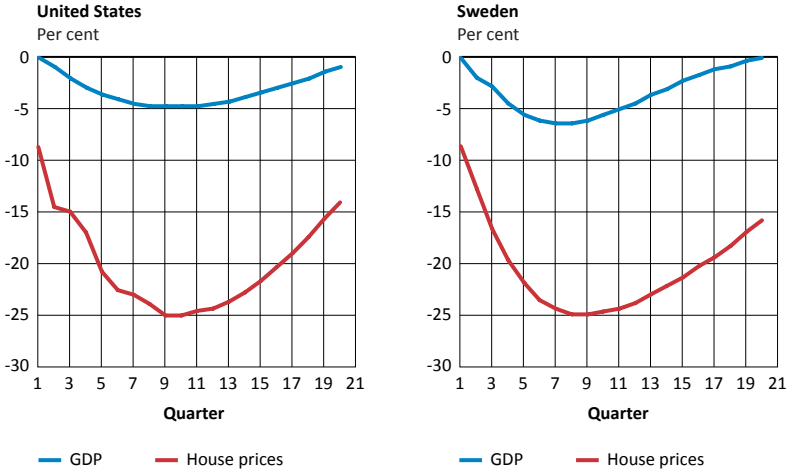
But how much of the fall in economic activity in the United States and Sweden can be explained by the fall in house prices? We know that that the crisis on the housing market contributed to the worst economic crisis in the United States since the Great Depression of the 1930s. The U.S. crisis in turn led to a global financial crisis in 2007-2009. But how much of the economic downturn that occurred can be reasonably attributed to house prices, and how large would the effects be on the Swedish economy of a major correction in house prices? To investigate this issue we estimate a simple bivariate regression system for GDP and house prices by applying the method of ordinary least squares, and study how large the effects on GDP will be if house prices fall by 25 per cent.[3] As we discussed above, this is approximately the same as the overall fall in US house prices in 2007-2009. We estimate the same model for the United States and Sweden to study how consistent the results are for both countries. According to the model, GDP would fall by about a fifth as much as house prices in the United States and by about a fourth as much in Sweden.

The results in Figure 2 imply that a large, unexpected correction in the housing market can result in a major downturn in the economy, and that a significant part of the fall in GDP during the financial crisis in the United States (and also the 1990s crisis in Sweden) was probably driven by the fall in house prices.[4]

3 The so-called "vector autoregressive" (VAR) models we estimate for the United States and Sweden contain real GDP and a real house price index (the one shown in Figure 1). We include a constant and a linear trend, and allow for 4 lags of the endogenous variables in the model. The estimation period runs from the first quarter of 1984 to the final quarter of 2015. GDP is first serialised in the VAR model, and we identify an exogenous shock to house prices with a so-called "Cholesky decomposition" where house prices are not assumed to affect GDP during the current period. This is the reason why the effects on GDP of the fall in house prices in Figure 2 are zero in the first period. This is an assumption which possibly moderates the effects of the house price fall on GDP slightly.

4 It is however important to point out that the results in Figure 2 are based on a simple bivariate regression system. If we include more variables and estimate a larger system (e.g. with international variables included) the influence of house prices on GDP tends to decrease. On the other hand, our assumption that house prices do not affect GDP during the current quarter tends to reduce the influence on GDP. Our overall assessment is, however, that the figures should be seen as an upper limit for how much house prices can affect the macro economy according to linear empirical models.

Figure 2. Possible GDP effects of a major fall in house prices

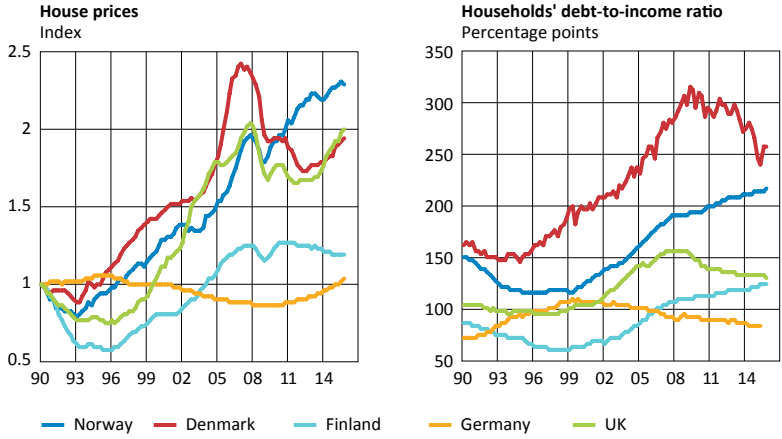


Note. Own calculations, see description of the VAR model that is estimated in Footnote 4.

As is well-known, the trend in rising house prices and indebtedness is not a phenomenon that is specific to Sweden today or to the United States before the financial crisis. As we see in Figure 3, house prices and household indebtedness have also risen sharply in other European countries, especially in Denmark up until 2009 and in Norway throughout the entire period. Germany is the exception that proves the rule: There, indebtedness and real house prices have basically remained constant since the beginning of the 1990s, apart from in recent years when prices have begun to move upwards.

In light of this, we believe it is important to study the extent to which the sharp rise in house prices since the 1990s crisis in Sweden can be explained by the relevant economic variables, or whether there is an obvious overvaluation which will sooner or later be corrected. We approach this important issue in two different ways.

Figure 3. House prices and household indebtedness in a selection of European countries



Note. House prices are in real terms (i.e. deflated by the CPI), seasonally adjusted and normalised to 1 in the first quarter of 1990.
Sources: House price index: Dallas FED; Debt/disposable income: National statistics offices and central banks

First, we analyse the valuation of Swedish houses from an international perspective. To do this, we have collected data on house prices, indebtedness and a number of key variables that can be assumed to be important for understanding house prices for all the countries shown in Figures 1 and 3 above. We then perform an analysis of the extent to which the development in house prices in these countries can be explained by these variables. Our method assumes that house prices on average are not overvalued for all the countries included in the study during the period studied, 1990-2015. Our method does, however, allow prices to be systematically over- or undervalued for individual countries, even for the period as a whole. Based on this analysis, we can then draw conclusions about the valuation of Swedish house prices from an international perspective.

As the price development has differed considerably among individual regions in Sweden, we also apply a regional perspective where we study the development of house prices on the municipal level. The analysis is important as it supplements the analysis we perform on the national level, and allows us to see whether the development in specific regions is particularly worrying. To perform this analysis, we have collected municipal data on house prices and earned income, which we use to study whether house prices in certain municipalities have increased by an unusual amount in relation to income.

Our study differs method-wise from the articles in the Riksbank's RUTH inquiry (mainly Claussen, Jonsson and Lagerwall 2011, and Englund 2011) in that we

apply a quantitative international perspective when assessing the house price development as a whole in Sweden. The studies in RUTH also use international experiences and comparisons, but not with a coherent quantitative method. Another obvious difference is that we can analyse developments since 2011, which is not insignificant since house prices have increased since then. It is perfectly possible that there were no obvious imbalances in pricing at that time, but that there are now. Further, no analysis was performed on the municipal level in RUTH, although there was a supplementary regional analysis in Englund (2011). A fresh study that takes detailed geographical information into account is Blind, Dahlberg and Engström (2016). Other relevant studies of Swedish house prices and any overvaluation of them are Birch Sørensen (2013), Giordani et al. (2015) and Turk (2015). Flam (2016) summarises a number of studies of Swedish house prices and the presence of a possible bubble.

The structure of the article is as follows: We begin in Section 2 by studying the development of house prices in Sweden as a whole from an international perspective. To do this, we first present the data we have collected and then the results of the analysis. After that, we study house price developments in different municipalities in Section 3. Finally, our conclusions and proposals for further analysis and measures are provided in Section 4.

2 International comparison

In this section, we describe our analysis of the pricing of Swedish houses from an international perspective. We start by presenting the data we use to explain price developments on the housing market in seven countries: Sweden, Norway, Denmark, Finland, the United Kingdom (UK), Germany and the United States (US). We then present our regression model and the results of the regressions in Section 2.2. Finally, we discuss how the results can be interpreted based on simple economic theory.

2.1 Data

In Figure 4, we present the data we use to assess the degree to which the development of house prices can be explained by macroeconomic variables These variables are normally used in econometric analysis in order to explain the development of house prices, see for example Claussen (2013), Englund (2011), Turk (2015) and Bauer (2014). Claussen (2013) used a slightly fewer variables than we do in his previous study of Sweden. In our analysis, we use real variables and allow inflation to affect house prices separately. More specifically, the following explanatory variables are included in our regression:

- real disposable income per capita
- real financial net wealth
- real mortgage rate
- annual CPIF inflation
- annual population growth
- residential investment as a fraction of GDP.[5]

As the dependent variable in the regressions, we use the house price indices shown in Figures 1 and 3 in the introduction. As far as Sweden is concerned, the nominal property price index for houses is used, deflated by the CPIF.[6] The property price indices for other countries are deflated with the CPI.

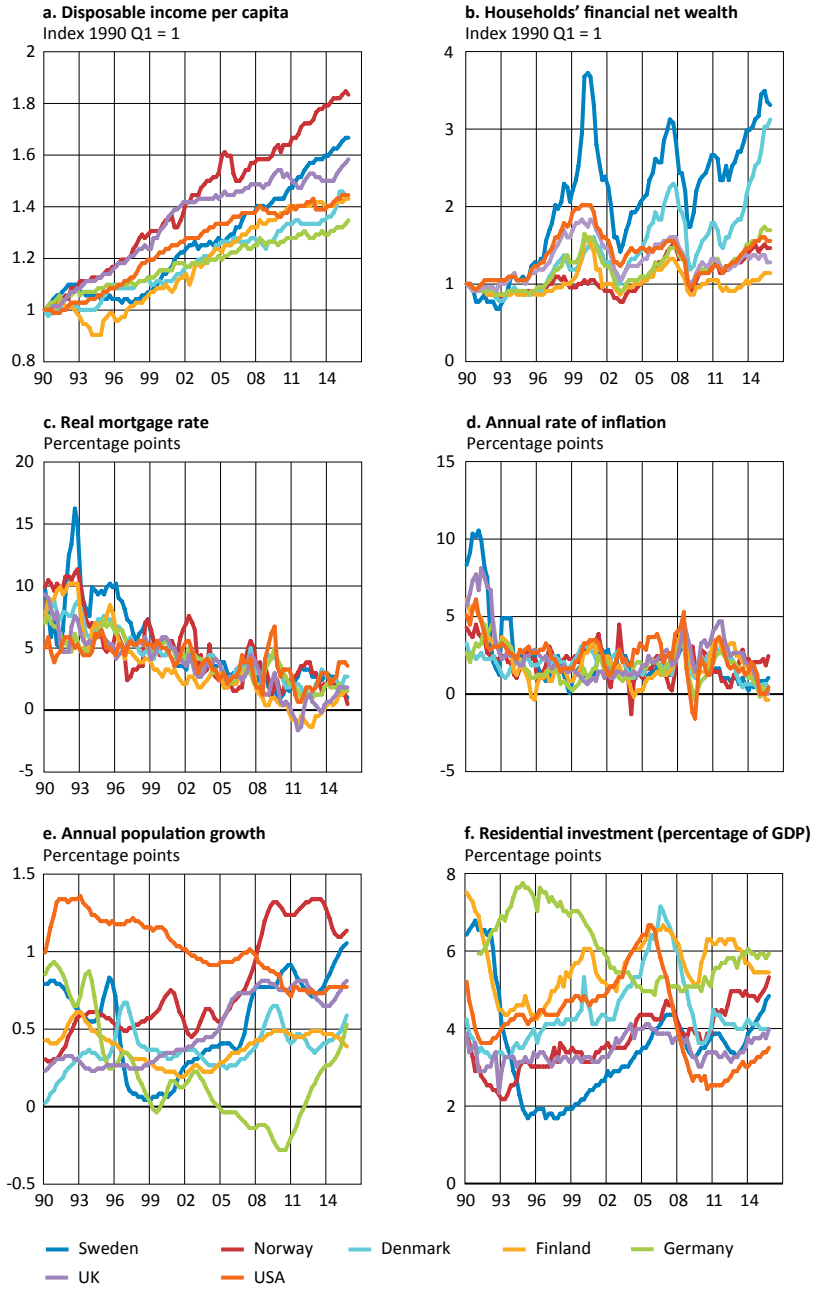
Let us now discuss the various explanatory variables shown in Figure 4. We are mainly interested in long-term, or low-frequency, changes. Please note first of all that mortgage rates have developed in a similar way in all the countries. Roughly speaking, inflation also seems to have the same long-term levels in all the countries studied. If we focus on Sweden, we note that financial net wealth has increased more in Sweden than in all the other countries. As regards disposable income, Sweden is the country in the sample that has the second-highest increase during the period 1990-2015. Population growth in Sweden is close to the average for all the countries during the period as a whole, but high from an international perspective in recent years. Finally, we note that residential investment as a percentage of GDP in Sweden was very low from an international perspective from the housing crisis of the 1990s up until 2006, but that investment in recent years has grown at a rapid rate and now amounts to almost 5 per cent of GDP, which is at the same level as the other countries. It is interesting to note that residential investment in Germany was very high from an international perspective during the 1990s, before falling back slightly in the 2000s. This may have had a restraining effect on German house prices in a way that is not necessarily captured by the development in residential investment in the other countries in our panel.[7]

5 For the following variables (i.e. those normalised to 1 in the first quarter), we take the natural logarithm: real house prices, real disposable income per capita and real financial net wealth. This only applies to the regressions, not when we show the variables in Figures, etc.

6 The CPIF is a price index for a broad consumption basket where housing costs are calculated with a fixed mortgage rate.

7 It is possible that residential investment in Germany has been so high as to keep the supply of houses high enough to satisfy demand, while structural problems (such as limited availability of land where people want to live and various bureaucratic obstacles, see Emanuelsson, 2015) may have led to insufficiently residential investment in other countries in order to provide an adequate supply of houses. In the latter countries, higher residential investment does not necessarily lead to lower price pressure, but only to less of an increase in prices than would otherwise have been the case. In these countries, increased residential investment becomes more of a measure of “surplus demand”, which means that residential investment can easily be given the wrong sign in a regression analysis.

Figure 4. Data for the explanatory variables: 1990 Q1 – 2015 Q4



Note. See Appendix A for detailed information about transformations of raw data.
Sources: See Appendix A

2.2 Regression analysis

We will now discuss the simple econometric approach we use. The basic assumption is that the dynamics in house prices have the same relationship to the fundamental variables in all the countries.[8] We are aware that this is a restrictive assumption and it should be seen as a starting point for further interpretation and discussion. It is, however, useful for our purpose and puts the valuation of Swedish houses in relation to how houses are valued in other countries. How restrictive this assumption is depends also on the model's capacity to explain the variation in house prices in the various countries. If our approach, which assumes that all variables influence house prices in the same way in all the countries in our study, cannot manage to explain the variation in house prices well, doubts can of course start to arise about this assumption. If we, on the other hand, find that the regression model does explain the house price variation in the various countries well, then it is a reasonable interpretation that our assumption is supported by the data.

To further simplify our analysis, we disregard differences in levels of variables that grow over time by converting the relevant variables into index series that are normalised to 1 for the start period in the empirical analysis (1990 Q1).[9] In line with this reasoning, we estimate a regression where the coefficients are the same for all countries:

$$(1) \qquad p^h_{i,t} = \beta_0 + \beta_y y_{i,t} + \beta_{nw} nw_{i,t} + \beta_{rr} rr_{i,t} + \beta_\pi \pi_{i,t} + \beta_{pg} pg_{i,t} + \beta_{ri} ri_{i,t} + \varepsilon_{i,t}.$$

In regression (1), β_0 is the intercept or constant term, β_y the coefficient for disposable income per capita, β_{nw} the coefficient for financial net wealth, β_{rr} the coefficient for the real mortgage rate, β_π the coefficient for inflation, β_{pg} the coefficient for population growth and finally, β_{ri} is the coefficient for residential investment as a percentage of GDP. In the previous studies by Claussen (2013), Giordani et al. (2015) and Turk (2015), a similar model approach was estimated exclusively on Swedish data in order to judge whether the sharp rise in house prices could be explained by the economic development since the financial

8 It was Paolo Giordani who suggested to us that it would be interesting to analyse Swedish house prices using an international panel approach.

9 Specifically, this normalisation is done for house prices (Figures 1 and 3), disposable income (Panel A in Figure 4) and financial net wealth (Panel B in Figure 4). Had we not done this, we would have been forced to allow for a country-specific constant term in the model. A country-specific constant had, however, involved an assumption that house prices in each individual country had been correctly valued on average over the estimation period, something which we wish to avoid in advance in our analysis. The normalisation does mean, however, that the average residual for each country contains the devation in the cointegrating vector between housing prices and the other normalized variables in the first quarter of 1990. Turk (2015) shows that this deviation is small for Sweden. We may therefore interpret our results in terms of over- and undervaluation of prices in levels for Sweden.

crisis in 2008, and largely found support to suggest that this was the case for the outcomes that were available when the studies were published. Since then, prices have continued to rise, but the economic fundamentals have also improved (e.g. real interest rates have fallen). We therefore do not believe that such an approach brings anything new to the debate.

We also estimate a variant of the regression model where we allow household debt as a percentage of disposable income (the debt-to-income ratio) to affect house prices through the coefficient β_{hd}:

$$p^h_{i,t} = \beta_0 + \beta_y y_{i,t} + \beta_{nw} nw_{i,t} + \beta_{rr} rr_{i,t} + \beta_\pi \pi_{i,t} + \beta_{pg} pg_{i,t} + \beta_{ri} ri_{i,t} + \beta_{hd} hd_{i,t} + \varepsilon_{i,t}. \quad (2)$$

As can be seen in a comparison of equation (1) and (2), the only difference between them is that the debt-to-income ratio is included in equation (2). If the coefficient β_{hd} is estimated as positive and significantly different from zero, and the model in equation (2) explains a significantly larger proportion of the variation in house prices in total and also in each individual country compared with the model in equation (1), this means that household indebtedness pushes house prices up, beyond the fundamental demand variables we have included in regressions (1) and (2).[10]

Some may consider it trivial that house prices are driven by household debt, as nearly all households have to borrow money from the bank when they buy a house. But such a reasoning ignores the fact that those who sell their house often significantly reduce their loan burden, so that total household indebtedness is not necessarily affected to any greater extent. It is therefore reasonable to interpret an estimation result $\beta_{hd} > 0$ in regression (2) as the supply of credit having a direct and quantitatively important significance for house prices, separate from the fundamental factors that govern the demand for houses.

Bearing this in mind, we will now discuss the estimation results of regressions (1) and (2), which are shown in Table 1. We start by commenting the coefficients in the model without the debt-to-income ratio, i.e. regression (1) above, the results of which are shown to the left in the table. Here, we have assumed that house prices in the long term increase as much as disposable income, i.e. the parameter value is 1. We introduce this assumption as a free estimation of this parameter results in a coefficient of 1.61, implying that house prices rise 1.6 times faster than income in the long term, which appears unreasonable given

10 Under the assumption that households' credit demand is explained by the same fundamental variables as in regression (1), the debt ratio should not be significant and add explanatory power in regression (2). A significant coefficient for the household debt ratio in regression (2) which adds to the fit of the model then shows that there is a significant supply effect of credit that is not fully captured by households' demand for loans.

the evidence in Giordani et al. (2015) who documents that real housing prices fall relative to real income per capita between 1875 and 2014.[11] We note that the model estimation captures the positive effect from financial net wealth, inflation and population growth as expected. One reason why it is reasonable to assume that inflation affects house prices positively is that it is nominal interest on debts that is tax-deductible in most of the countries. When inflation increases, households' real interest expenditure decreases after tax. The relationship between the real interest rate and house prices is estimated at -1.5, i.e. with an expected negative sign but with a very low value – the vast majority of economic models imply that house prices are significantly more sensitive than that to changes in interest expenditure. However, our estimated coefficient line up well with the IMF's (2005) result (-1 to -2) for eight euro countries. The coefficient for residential investment is positive. But this should not be interpreted as residential investment driving up house prices, but rather as the presence of an underlying unobserved factor that drives up both house prices and residential investment. If we look at the *p*-value in the table (p-val), we can see that all coefficients bar one are significant even when using a high significance level. It is only the significance for inflation that is low (only significant on the 10-percent level).

11 It is important to realise that the model's explanatory power for all countries is almost entirely unaffected by this restriction, which means that other variables substitute for the greater importance given to disposable income in an unrestricted model.

Table 1. Regression results for panel models of house prices

	Model without debt-to-income ratio			Model with debt-to-income ratio		
Variable	**Coeff.**	**Std. Dev.**	**p-val**	**Coeff.**	**Std. Dev.**	**p-val**
Disposable income	1.00	--	--	1.00	0.04	0.0000
Net wealth	0.23	0.02	0.0000	0.07	0.01	0.0000
Residential investment	2.70	0.55	0.0000	3.38	0.29	0.0000
Real mortgage rate	-1.55	0.31	0.0000	-0.57	0.22	0.0104
Inflation	0.93	0.53	0.0766	1.01	0.29	0.0409
Population growth	23.06	2.08	0.0000	18.18	1.23	0.0000
Debt-to-income ratio	--	--	--	0.33	0.01	0.0000
Models' explanatory power - R^2_{adj}						
	Model without debt-to-income ratio			**Model with debt-to-income ratio**		
Total	**0.74**			**0.93**		
Individual countries						
Denmark	-0.41			0.84		
Finland	0.61			0.89		
Norway	0.91			0.94		
UK	0.74			0.80		
Sweden	0.87			0.94		
Germany	-4.91			-0.68		
US	0.15			0.89		

Notes: The estimated models contain house price index, disposable income and financial net wealth in natural logarithms. A constant is included in both models but not shown in the table. The table reports the estimate coefficients ("Coeff.") for all explanatory variables and standard deviation ("Std. Dev") and p-value ("p-val") for these coefficients. Standard deviation is a measure of how precise the estimation is while the p-value denotes the probability that the coefficient has the stated sign. R^2_{adj} denotes the models' adjusted explanatory power and takes into account that the model with indebtedness contains an extra parameter compared to the model that does not include indebtedness.

The right-hand side of Table 1 shows the results for the model that includes household indebtedness as an extra explanatory variable (equation 2 above). As regards estimated coefficients, the model specification that includes the debt-to-income ratio differs only marginally from the main specification in regression (1) with the difference that we no longer need to add the restriction that the coefficient for disposable income is 1. The estimated coefficient will be estimated

to almost exactly 1 in any case. Another difference is that with equation 2, the coefficients for net wealth and mortgage rate will be lower. One might assume that this is due to a high degree of so-called multicollinearity (covariation) between these variables, i.e. that lower real interest rates drive up net wealth and household indebtedness. In that case, it would be difficult to identify how much influence the various variables actually have. The argument against this is that the standard deviations for both net wealth and the real interest rate fall when indebtedness is introduced. The coefficients for these variables are therefore estimated more precisely. The coefficient for household indebtedness is very precisely estimated and quite clearly helps to improve the model's capacity to explain the variation in house prices. As is evident from the first row in the table under the estimated coefficients, the adjusted explanatory power for all countries in total increases from 0.74 to 0.93 when household indebtedness is included.[12] This is a clear improvement.

We also see in the right-hand column in Table 1 that the coefficient for the debt-to-income ratio is estimated to a third. Given that all the variables in the regression are exogenous in relation to each other in the long term, this means that the increase that has occurred in indebtedness from around 100 to 175 per cent during the 2000s gives a direct contribution to house prices of 25 per cent. By interpreting the results in this way, we derive a simple measure of how much house prices could feasibly be corrected downwards if economic policy measures were implemented to push down indebtedness. At the same time, it is important to remember that we then assume that the economy is not otherwise affected by these measures. At least in the short term, such an assumption is therefore unreasonable, as there is a high degree of covariation among several of the variables in the regressions.[13]

What are the implications of the two models for house prices in the different countries during the estimation period? Let us begin by looking at the regression results graphically in Figure 5. The Figure shows the actual house prices and the fitted (estimated) values from the regression model without the debt-to-income ratio. We can draw four main conclusions from this figure:

1. According to this method, house prices in Sweden at the end of 2015 are well in line with the fundamentals, or are at least not obviously overvalued.

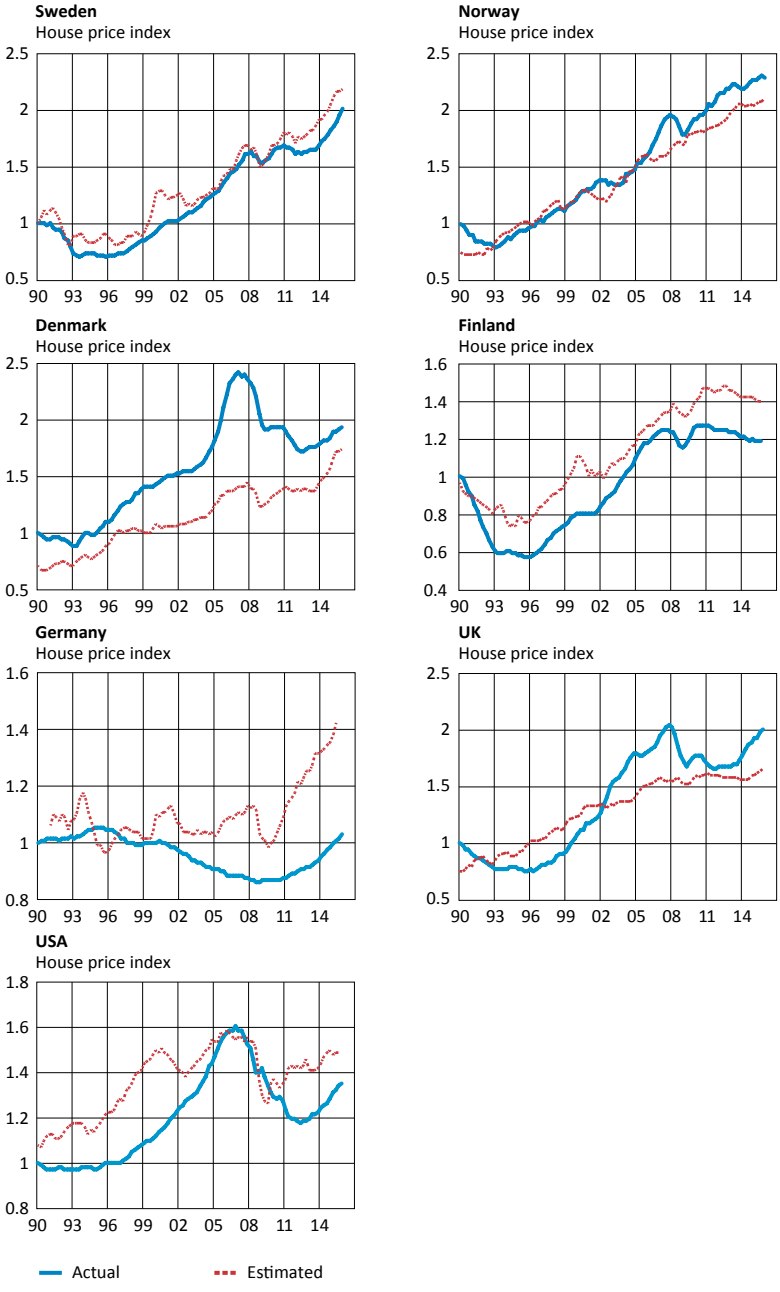
12 The total explanatory power is a weighted average of the model's explanatory power for the various countries in the lower section of the table, where the weight for each individual country is equal to the variance in house prices in the country as a proportion of the sum of the variances for all countries. As Germany has relatively low variation in house prices (as can be seen from Figures 1 and 3), it follows that Germany is given a relatively small weight in the calculation of the total explanatory power, which explains why the total explanatory power is so high in the model without indebtedness, despite Germany having a very negative explanatory power.

13 See, for example, the article by Finocchiaro, Jonsson, Nilsson and Strid (2016).

2. In some cases, estimated and fitted house prices tend to deviate from one another for many years in a row for an individual country. For example, estimated house prices are lower than the actual ones for the entire period in Denmark while the converse is largely true for Finland. A possible interpretation of this is that changes in factors outside the model are also important, and probably country-specific. It may, for example, be a question of changes in differences in institutions, norms or credit supply. As we mentioned previously, another possible explanation is that the variables we include affect house prices in different ways in the various countries.
3. Sharp and rapid rises in house prices tend to not be motivated by fundamentals according to our model. Examples of this include the upturns in Denmark in 2004-2008, in the UK in 2002-2008 and the smaller, temporary upturn in Norway in 2006-2008. The results for the house price boom in the United States is more ambiguous, however. The prices do increase more rapidly than the model implies, but from an undervalued level. Despite this, it is a problem for our approach that it does not identify an overvaluation problem prior to the sharp fall in prices in the United States.[14] Further, gaps between estimated and actual house price series in these cases tend to closed by actual prices falling. We see this as an indication that our model is actually useful – deviations are identified at least *ex post* from long-term prices. Our conclusion is therefore that the difference in dynamics among countries is not particularly large and we therefore deem our approach to be meaningful.

14 In Appendix B, we show that a variant of the model without net wealth included indicates that a substantial overvaluation prevailed in the United States prior to the onset of the sub-prime crisis in August 2007. The results for the United States are therefore not robust for the choice of explanatory variables.

Figure 5. Actual and estimated house prices from the regression model without indebtedness (regression in equation 1)



Note. The estimated prices (dashed red lines) have been calculated using the estimated coefficients reported in the left-hand column in Table 1.

4. House price development in Germany is completely different from the other countries. If prices in Germany had had the same relationship to the fundamentals as in the other countries, they had been 40 per cent higher than they are now. We also see a tendency towards an acceleration in house prices in Germany since 2011 in the figure. As Germany is so different, this result raises the question to what extent the results in Table 1 would have been affected if we had excluded Germany. We will return to this question a little later on, in Section 2.3.

How are the results affected by the fact that we include household indebtedness? The fitted house prices according to the model with indebtedness (model 2) are shown in Figure 6. We note that the difference between actual and fitted prices is much smaller in this model specification. This means that the model has a higher explanatory power than the model without indebtedness. We can also see this from the explanatory power in Table 1. As in the model without indebtedness, price increases that do not have support in the fundamentals tend to be corrected by actual house prices falling. Another similarity with the model without indebtedness is that the current actual house prices in Sweden are close to the house prices predicted by the estimated regression. It is only in the UK that actual house prices are significantly higher than estimated prices at the end of the period in both models. The fact that prices in the UK are higher than predicted also based on household indebtedness may possibly be due to foreign investors having been responsible for a substantial proportion of the purchases.[15] When foreign investors purchase UK houses, the indebtedness of UK households does not rise, but capital inflows increase and sterling tends to rise in value in relation to other currencies.

For several countries, especially Denmark and Norway, the inclusion of indebtedness means that the gap between actual and predicted house prices basically closes. Does this mean that we should view the house price increases in these countries as consistent with the fundamentals? That depends on the perspective we take on indebtedness. If the rising indebtedness is *demand-driven by realistic* expectations of high incomes and permanently low mortgage rates in the future that are not captured by current income and mortgage rates, the prices can reasonably be seen as fundamentally determined. An example of this would be if the real mortgage rate is expected to be more persistently low than historical patterns indicate. In that case, a major downward correction of either house

15 About 10 per cent of the UK housing stock is owned by foreign citizens and companies (Valentine, 2015), and Badarinza and Ramadorai (2015) find support for the thesis that foreign ownership has driven up prices. Other studies, such as Marsden (2015) and Hilber and Vermeulen (2016) highlight problems on the supply side instead.

prices or indebtedness is not necessary as households' debt-to-income ratio tends to fall gradually over time when their income rises and low interest rates prevail. In this case, household indebtedness can also increase without it necessarily leading to a major correction in prices and indebtedness in the future. But if the increased indebtedness is instead *supply-driven*, and is due to willing borrowers being offered the chance to borrow capital at unusually low rates of interest during a limited period, the situation may be more troublesome.[16] The day when credit supply significantly and unexpectedly declines, the costs of household borrowing will substantially increase. Market rates will then increase, households will be forced to spend more of their income on servicing their debt, which will consequently reduce their scope to consume other goods. To release resources in order to consume other goods, households will want to reduce their debt burden in this situation. All in all, this scenario therefore leads to a sharp fall in household demand for companies' goods and services, resulting in a decline in companies' demand for labour. This leads, in turn, to a fall in households' disposable income and in their financial net wealth due to a lower valuation of companies' future profits and higher discounting of these. Falling disposable income and net wealth combined with higher interest rates create downward pressure on house prices according to our regression model in Table 1, and the downward correction of the debt-to-income ratio may contribute further. In this way, an increase in indebtedness that is not entirely motivated by fundamental factors can be a problem for the economy.

We can also exclude Sweden from our regressions to answer the following question even more literally: "If house prices in Sweden had developed according to the same pattern as in other countries, what would they then have been?" But this exclusion has only negligible effects on estimated house prices – the four conclusions above still hold up. However, the estimated values of the coefficients sometimes change noticeably. This is particularly true for the model without the debt-to-income ratio and suggests that some of the coefficients are less robust.[17]

Finally, we note that the four conclusions, including the absence of an obvious overvaluation of Swedish house prices at the end of 2015, hold up even if we exclude net wealth from the regression. This is an important robustness exercise as it is plausible that the overvaluation of housing coincides time-wise with the

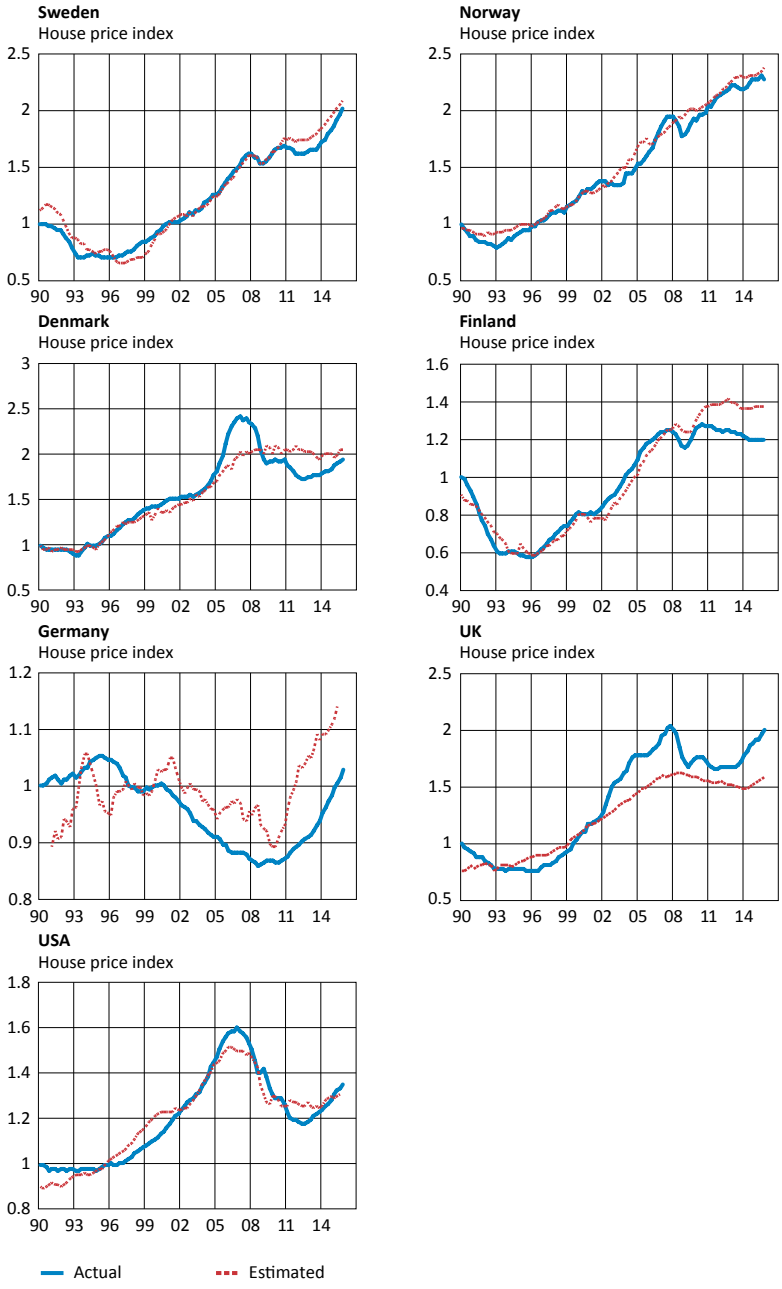
16 Unrealistic expectations of future income and interest rate levels have, in all likelihood, qualitatively similar effects to a temporary increase in capital supply that pushes down interest rates and contributes to greater economic activity in the near term.

17 While the coefficient for the debt-to-income ratio is still highly significant and virtually unchanged (0.33), the coefficient for the real interest rate becomes positive and non-significant when Sweden is excluded from the panel in the model with the debt-to-income ratio. In the next section, we discuss the interplay between real house prices and the real interest rate in more detail, and look at why the uncertainty regarding its impact is so substantial in our models in Table 1.

overvaluation of other financial assets. In fact, dropping net financial wealth as an explanatory variable improves the fit of the models for Sweden, because of our constructed Swedish net financial wealth series is so volatile (see panel b in Figure 4). We present the results for this simplified variant of the regressions in equations (1) and (2) in Appendix B.

In conclusion, there is no obvious overvaluation of the Swedish housing stock as a whole, since even the model that does not include indebtedness indicates that the valuation of Swedish houses is in line with fundamental variables. But since the model that includes indebtedness fits the data better, both internationally and for Sweden, there is nevertheless a risk that prices and the high level of indebtedness are not sustainable in the long term if the supply of capital decreases and interest rates rise rapidly. Further, it is important to note that these results only apply to the country as a whole, and do not say anything about valuation in individual municipalities. We will discuss pricing in individual municipalities in Section 3. But before we do, we will discuss the interpretation of the regression results in a little more detail based on existing economic theory.

Figure 6. Actual and estimated house prices from the regression model with indebtedness (regression in equation 2)



Note. The estimated prices (dashed red lines) have been calculated using the estimated coefficients reported in the right-hand column in Table 1.

2.3 How can the regression results be interpreted?

In this section, we present what economic theory says about the share of household expenses that go to housing and what that means for house prices in the long term. An important concept in this context is "user cost", that is the cost of owning and using a home as a share of its price. The user cost for housing (*uc*) includes a financial cost comprising the real interest rate for the mortgage (or the return on another investment with a risk similar to housing) and other components, such as property tax, tax relief on interest expenditure and expected house price increases, as well as costs for operation and maintenance.[18]

Economic theory and empirical data support the idea that households will in the long term choose to spend a fixed proportion of their income on housing.[19] We can then calculate what these housing costs signify for house prices. We do that both with a macroeconomic model, Walentin 2014, and in the simplest possible way.

Let us begin with the simple method. We can express the housing expenditure share in the long term, HES, as

$$HES = \frac{r^* p^h \overline{h}}{y}, \tag{3}$$

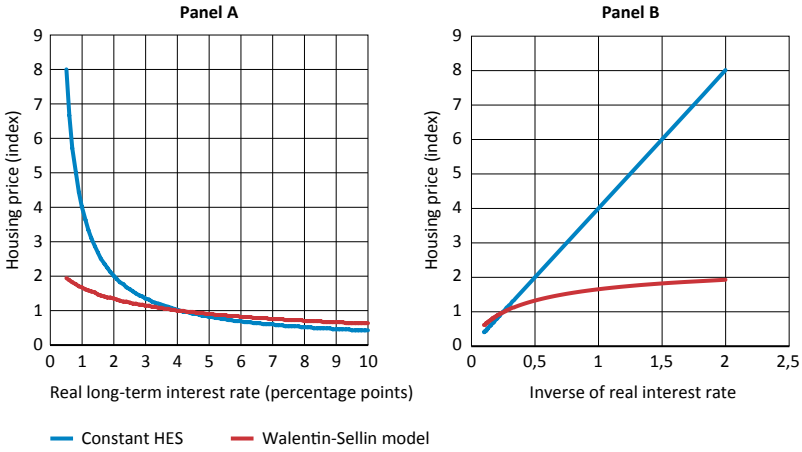
Where r^* is the real interest rate in the long term, p^h is the real house price, $\overline{h}$ the housing stock and y the real disposable income per capita. We assume that $\overline{h}$ is constant in this reasoning. The relationship in equation (3) is of course a stylised picture of the real housing cost in that we use the real interest rate instead of the user cost for housing. In other words, we disregard property tax, tax relief on interest expenditure and expected house price increases as well as the costs for operation and maintenance, as they are difficult to measure over time in many countries. We discuss the interplay between r^* and *uc* below, but assume for the time being that variations in r^* are the most important source of variations in *uc* in the long term. This is often a reasonable assumption possibly with the exception of property tax changes.

An important insight from equation (3) is that the relationship between the real interest rate and house prices is non-linear. A change in the real interest rate from 6 to 5 percentage points is not a big issue, but a fall from 2 to 1 per cent provides major leverage on house prices if *HES* is assumed to be constant. The interplay between the real interest rate and house prices is illustrated in Figure 7.

18 See Englund (2011) for a detailed discussion of the user cost for housing.

19 Cobb-Douglas preferences for consumption over housing services and consumption of other goods and services imply that households spend a constant share of their income on housing in the long term. For example, the influential article by Iacoviello (2005) makes this assumption.

Figure 7. Relationship between user costs and house prices



The blue line in Panel A in the figure ("Constant HES") indicates the value of p^h which, according to equation (3), implies a given housing expenditure share, HES, when we vary the real interest rate, r^*, along the x-axis. The red line in the same figure ("Walentin-Sellin") indicates the long-term house price that the model from Walentin (2014) implies.[20] The main differences compared to equation (3) is that the Walentin-Sellin model takes into account the fact that

i. the housing stock is adjusted upwards when house prices rise over the long term (*h* in equation (3) increases)

ii. user costs include not only interest but also operation and maintenance costs for the house of 4 percentage points annually.

Both these aspects moderate the change in the house price that an interest rate change implies and is quantitatively of about the same importance. A long-term reduction in the annual real interest rate from 4 to 1 percentage point leads to, according to this model, an increase in the housing stock of 54 per cent, which is a substantial increase. If such an increase in the stock cannot materialise, the price pressure will be higher in the model. Despite the large increase in the stock, such a long-term reduction in the real interest rate will lead to the price of housing rising by 65 per cent, according to Walentin-Sellin.

Panel B in Figure 7 instead indicates the relationship between the inverse of the real interest rate (1/the real interest rate) and the house price. A fixed housing expenditure share, "Constant HES", implies a linear relationship between these

20 The house price is normalised to 1 when the real interest rate is 4 per cent in both models.

variables, while Walentin-Sellin implies that the house price is a concave function of the inverse of the interest rate, because the supply of housing increases when the real interest rate persistently falls and the user cost includes not just the interest rate, as we have discussed previously.

What do these relationships look like in actual data? The regressions in Table 1 indicated quite a low coefficient for the real interest rate, but the regressions were done for a predominant proportion of high outcomes for the real interest rate (see Panel C in Figure 4), which implies that the estimated coefficient should be limited according to the reasoning concerning equation (3) above. We therefore now perform a more direct test of the theoretical, long-term relationship between the inverse of the real interest rate and house prices by studying the actual relationship between these variables for each country in Figure 8. A value of 1 on the x-axis in Figure 8 therefore means that the real interest rate is 1 per cent, and a value of 0.5 that the real interest rate is 2 per cent. Most of the values on the x-axis are below 1 as real interest rates have fallen over time from quite high levels.[21] This can be seen, for example, in Panel C in Figure 4. Apart from data, the panels also contain the concave relationship implied by the Walentin-Sellin model and the linear pricing relationship implied by a constant housing expenditure share for a fixed housing stock (HES in equation 3).[22] We note that an overwhelming proportion of the observations tend to be between these two lines. The simple linear regression is not suitable for Germany in particular, but also for the United States. As far as Germany is concerned, we see, surprisingly enough, a negative relationship between the inverse of the real interest rate and house prices, which is in strong contrast to economic theory.[23]

If we disregard Germany, the overall impression from the figure is that, although prices have not risen as much as a constant housing expenditure share

21 We should also bear in mind that the theoretical relationship is between long-term levels of the real interest rate, while the data is for real mortgage rates with interest-rate fixation periods that vary from one country to the next. Internationally speaking, Sweden and the UK, for example, have a low average interest-rate fixation period of about 2 years. Despite this, the linear relationship is suitable for both these countries. Surprisingly enough, the relationship is less suitable for the US, which is a country with long interest-rate fixation periods, i.e. the current interest rate is a long-term interest rate.

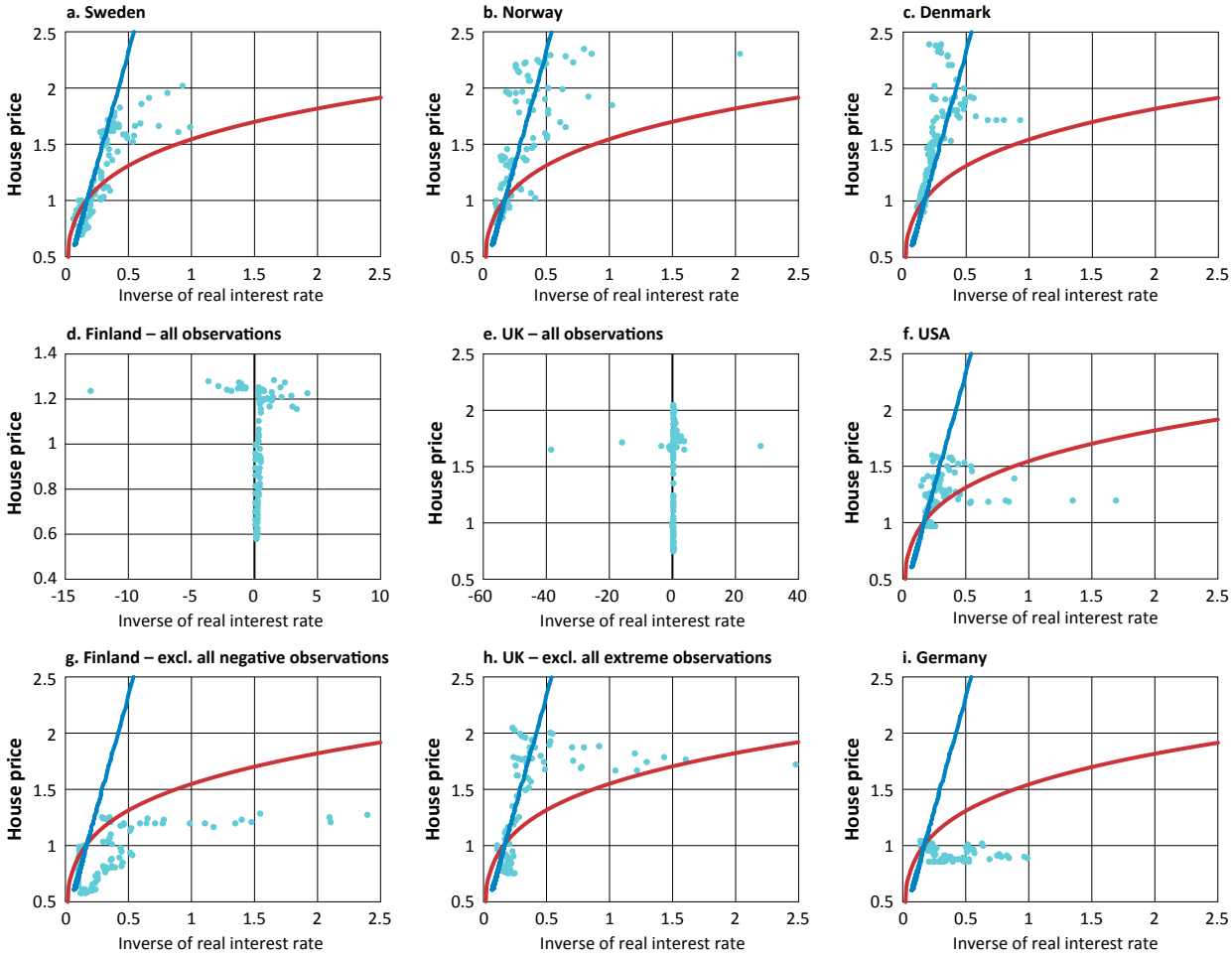
22 To be able to compare the results for Finland and the UK with the other countries in a better way, we exclude in Panels G and H all observations that have a negative real interest rate along with an observation for the UK that has a very low real interest rate (0.036 percentage points, which implies an inverse of 28). Panels D and E show the results for all observations included (but without the models).

23 The fact that Germany has such a divergent relationship between house prices and the real interest rate, and that there are a couple of large "outliers" in the real interest rate for Finland and the UK (which is indicated by Panels D and E in Figure 8) means that the coefficient for the real interest rate is pushed down in our estimated regression models in Table 1. If we re-estimate the models and exclude Germany and these observations for Finland and the UK, the coefficients for the real interest rates increase sharply, but household indebtedness is still strongly significant. Our earlier conclusions are not therefore affected. In future work, it would be desirable to compute real rates as the nominal rate minus long-term inflation expectations rather than subtracting the yearly change in the CPI as we did.

with a fixed supply of housing would imply, prices have in general risen more than what is implied by the Walentin-Sellin model with an endogenous (increased) supply of housing. This is probably explained by the fact that several countries find it difficult to increase the effective housing stock; it is often said that countries such as Denmark, Norway, the UK and Sweden have structural difficulties to increase the supply of housing in locations where people want to live.[24] This analysis therefore also indicates that although Swedish houses are currently very highly valued, it is difficult to claim that they are obviously overvalued. The prices can nevertheless be corrected downwards if the supply increases sharply, but we know that this is politically difficult to achieve.[25]

24 See Hilber and Vermeulen (2016) for a discussion on supply problems in the UK. The IMF (2016) discusses supply problems on the Danish housing market and Emanuelsson (2015) the supply problems in Sweden.
25 See Emanuelsson (2015) for a detailed discussion of various political obstacles to increasing the supply of housing in Sweden.

Figure 8. Long-term relationship between the inverse of the real interest rate and house prices



Note. The blue line describes the relationship between house prices and the inverse of the real interest rate according to a constant housing expenditure share (equation 3). The red line is the theoretical relationship according to the Walentin-Selling model. Both lines are taken from Panel B in Chart 7. House price data for Finland and the UK (SB) is reported twice – first the complete dataset (Panels D and E) and then with the same scale as for all the other countries (Panels G and H) where all negative observations have been excluded. Additionally, for both Finland and the UK, extreme values (>2.5) of the inverse real rate have been excluded. Both lines have been normalised so that they intersect at the point at which house prices are 1 and the inverse of the real interest rate is 0.167 as this is the case in the start period for our sample (1 follows from the normalisation of house prices we did in the first quarter of 1990, see notes on Charts 1 and 2).

3 Analysis on the municipal level

We now study how house prices have developed in individual municipalities in Sweden, and whether we can draw the conclusion that the price development in individual municipalities is justified by the income development and the fall in real interest rates, or if prices in certain municipalities have risen much more.

We start by describing the data that we have at our disposal, and then present the results from our simple regression analysis.

3.1 Data

On the municipal level, there is annual data on median earned income available from Statistics Sweden.[26] Furthermore, there is data on the mean value for house prices per municipality available per year.[27] Please note that the data here concerns the price of a house in that municipality, $\tilde{p}^h_{j,t}$, not the quality-adjusted price per square metre, $p^h_{j,t}$. If we assume that households pay the same interest and property tax, we can calculate from the house price and disposable income the share of income that households in each municipality *j* spend on their housing in year *t* according to the following formula:

$$HES_{j,t} = \frac{uc_t \tilde{p}^h_{j,t}}{y_{j,t}}. \tag{5}$$

In equation (5), $HES_{j,t}$ represents the share of income, $y_{j,t}$, that homeowners in municipality *j implicitly* spend on their housing. We write implicitly because this is a calculation based on a so-called "user cost", i.e. a calculation where the cost is calculated as if the household constantly borrows the entire current price of the home from a bank and pays property tax. As mentioned above, we assume here that this user cost, uc_t, is the same in all municipalities. We approximate uc_t with a nominal mortgage rate adjusted by actual inflation, tax relief on interest expenditure and property tax according to the following formula:

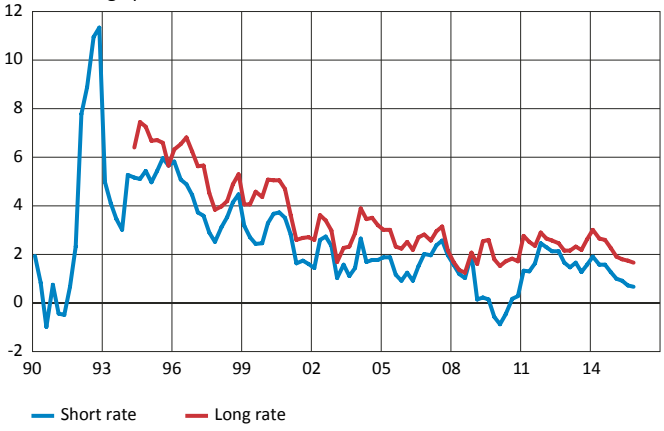
$$uc_t = i^{loan}_t (1 - \tau_t) - \pi^e_t + fs_t. \tag{6}$$

In equation (6), i^{loan}_t represents the nominal mortgage rate, τ_t the share of interest expenditure the household can deduct from income tax, π^e_t expected inflation (measured as the previous year's inflation) and fs_t the effective property tax rate (in per cent). We disregard operational and maintenance costs, which are reasonable if they are approximately constant. Figure 9 shows the time series for

26 Statistics Sweden. Purchase price for houses.
27 Statistics Sweden. Aggregate earned income per municipality, per individual over the age of 20.

uc_t for two different measures of the mortgage rate; a rate with a short (3-month) fixation period and one with a long (8 year) fixation period. The average interest-rate duration for Swedish mortgages has fallen considerably since the housing crisis of the 1990s, and in that regard, the user cost series based on the short-term mortgage rate in Figure 9 is a more accurate measure of what the household has actually paid over the last decade.[28] Nevertheless, the user cost series based on the long mortgage rate is relevant as it measures what households should expect to pay over a longer period in the future if we assume that the long-term mortgage rate is approximately equal to an average of expected short-term interest rates.[29]

Figure 9. Swedish user cost for housing (percentage points) calculated with short and long-term mortgage rates
Percentage points



Note. Short interest rate refers to 3-months maturity, whereas the long interest rate refers to 8-years maturity.

Another property of the user cost measure in equation (6) is that it implicitly assumes that real house prices are expected to be constant. If the household expects a rise in house prices by a certain percentage, the effective housing cost would need to be reduced by an equivalent percentage (adjusted for the capital gains tax rate), as an expected increase leads to ownership of the home

28 The proportion of variable rate mortgages in the stock of mortgages has gone from below 20 per cent to above 60 per cent from 1998 to 2015 according to the 2016 Financial Stability Report.

29 The expectation hypothesis implies that the long-term interest rates is equal to an average of present and future short interest rates plus a risk and liquidity premium. The long-term interest rate we use to calculate the user cost series in Figure 9 still contains a risk premium, and therefore gives a certain overestimation of the expected future housing cost when the household borrows with a short fixation period. As long as the risk premium is constant, we catch the variation in future expected interest expenditure well. Historically, however, there is considerable time variation in this risk premium.

being worth more in the next period. On good grounds, we can question this simplified assumption as Figure 1 shows that the real house prices for the country as a whole have increased at a quite steady rate since the housing crisis at the beginning of the 1990s. But it is important to differentiate between actual and expected increase. If everyone had expected a steady increase in real house prices for a number of years in the future already in 1995, prices should have reached current levels as early as at the end of the 1990s. It therefore seems reasonable to assume that market participants did not expect an increase in real house prices of the scale that has actually been recorded.

Still, it may be reasonable to make a certain adjustment to the user cost for an expected house price increase, especially bearing in mind that the trend in productivity growth in the construction sector is below the rest of the economy otherwise, which tends to drive up real house prices in the long term. But as we neither have access to any good measures of real house price expectations nor to productivity differences between the housing sector and other sectors, we do not make any adjustment for this effect. As a result, there is a clear tendency for both user cost series in Figure 9 to overestimate the effective housing cost. On the other hand and as mentioned above, we disregard operational and maintenance costs when we calculate the user cost. This gives a tendency in the opposite direction, towards underestimation of the user cost.

Bearing in mind this discussion of the effective user cost for housing, we use uc_t based on the long-term mortgage rate to calculate households' housing expenditure share for ($HES_{j,t}$ in equation 5 above) in Table 3 for a number of selected municipalities and the country as a whole.[30] Since we don't have data on income for the house-buyers in the various municipalities, we also implicitly assume that the house-buyers have the same income as other residents in the municipality. This assumption can be misleading in the municipalities where house prices have increased the most. In these municipalities, it seems reasonable to assume that the income of house-buyers exceeds the median income of the existing residents. Further, the assumption is problematic for municipalities where the median earned income is very different for house-owners compared to other local residents, such as those who rent their home.

In addition, there is a debatable assumption that affects the expenditure shares in table 3, namely that the income data we use is for earned income. The theory applies instead to housing costs as a share of total income. As a consequence, municipalities with a large share of other income, mainly income from capital, will be incorrectly seen as municipalities with a high housing

30 Even though we have annual data at our disposal, we only show the results for every 5th year starting in 1995.

expenditure share. It is possible that this income from capital partly explains the high expenditure share for housing in, for example, Danderyd in Table 3 below.

Table 3. Households' expenditure share for housing in selected municipalities and in the country

Municipality	1995	2000	2005	2010	2013	2014
Båstad	0.44	0.41	0.27	0.23	0.27	0.39
Danderyd	0.91	0.90	0.49	0.37	0.61	0.72
Göteborg	0.53	0.51	0.36	0.28	0.38	0.45
Lidingö	0.78	0.88	0.49	0.40	0.62	0.75
Linköping	0.37	0.34	0.25	0.18	0.25	0.29
Malmö	0.51	0.55	0.41	0.32	0.39	0.45
Nacka	0.63	0.70	0.42	0.33	0.48	0.56
Norrköping	0.34	0.29	0.21	0.16	0.22	0.25
Solna	0.65	0.92	0.56	0.41	0.55	0.72
Stockholm	0.54	0.63	0.40	0.30	0.44	0.52
Sundbyberg	0.62	0.82	0.45	0.39	0.51	0.58
Umeå	0.36	0.32	0.21	0.16	0.21	0.26
Uppsala	0.42	0.40	0.27	0.21	0.30	0.35
Västerås	0.38	0.32	0.25	0.17	0.22	0.27
Örebro	0.33	0.31	0.20	0.15	0.21	0.26
Country – mean	0.25	0.20	0.13	0.10	0.13	0.16
Country - median	0.22	0.17	0.10	0.08	0.11	0.13

We can also see in Table 3 that there is a substantial variation in the expenditure share for housing. Unsurprisingly, the share is lower in rural areas and in smaller towns than in the metropolitan municipalities listed in Table 3. Therefore, it will also be lower in the country on average. As regards to changes over time, we note that the share in 2014 is not unusually high from a historical perspective. This is due to the fact that the user cost has fallen more since 2000 than house prices have risen, at the same time as income growth has been good. The expenditure share has, however, risen sharply since 2010, especially in metropolitan municipalities, reflecting that prices have risen much more than income and that uc_t have been almost unchanged during this period (see Figure 9).

In summary, there is strong upward price pressure in the country as a whole and in metropolitan municipalities in particular. But thanks to the low user cost, households' expenditure share have remained normal or even lower than normal from a historical perspective, at last until the end of 2014.[31] In the next section, we perform a slightly more rigorous analysis which results in the same conclusion.

3.2 Regression analysis

In light of the descriptive analysis in the previous section, we now perform a simple regression analysis. The aim of this is to investigate whether housing costs as a share of income in *individual municipalities* have developed in an unusual way more recently. To perform this analysis, we estimate the following simple regression where we assume that the housing expenditure share in municipality j, $HES_{j,t}$, depends on the earned income in the municipality relative to the average earned income in other municipalities in period t:

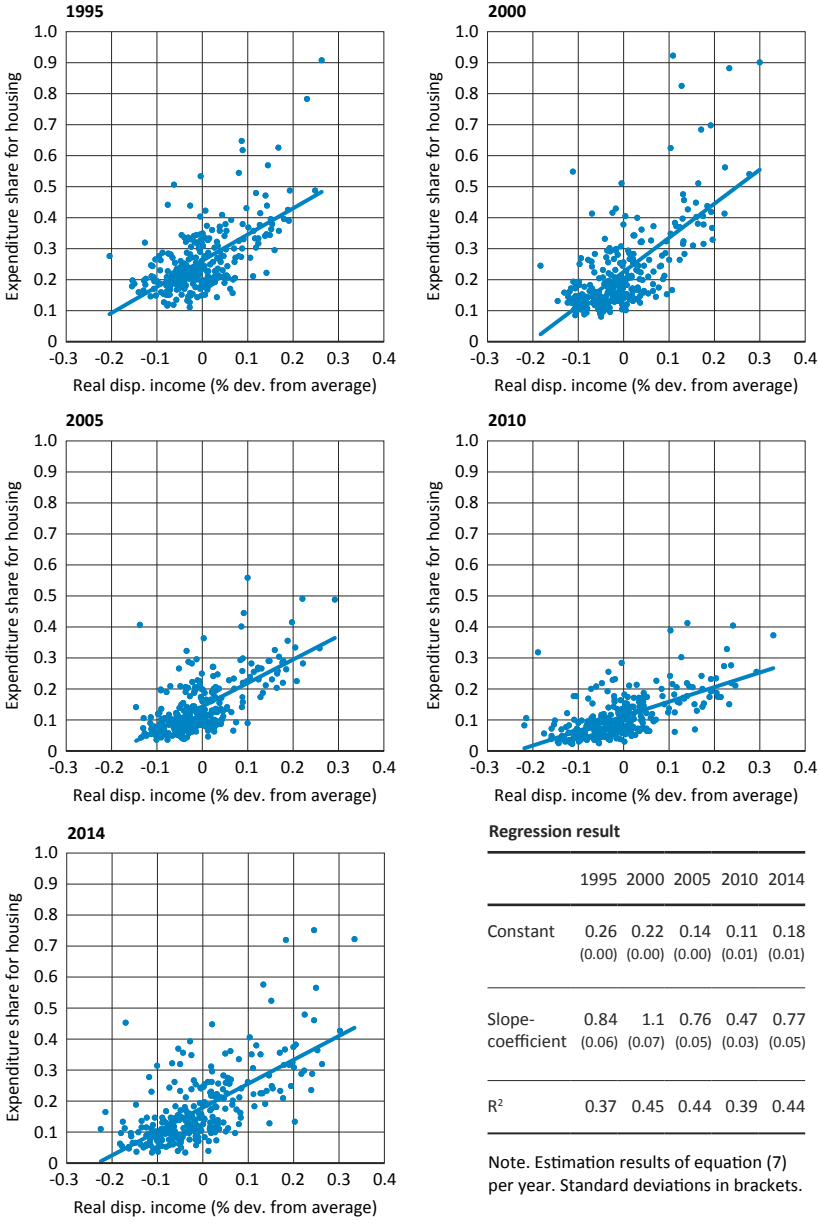
$$HES_{j,t} = \beta_{0,t} + \beta_{1,t} (\ln y_{j,t} - \ln \bar{y}_t) + \varepsilon_{j,t}. \tag{7}$$

There is no underlying theory behind the regression specification in equation (7), but Table 3 supports our assumption that households in municipalities with a high level of income spend a greater share of their income on housing. It is, however, important to remember that by allowing for this in the analysis, we purge a systematic income effect when we study whether the expenditure share has risen by an unusual amount in individual municipalities more recently.

We estimate the regression in equation (7) every 5th year for all n=290 municipalities. We are interested in three aspects of the regression. Firstly, we want to know whether $\beta_{1,t}$ has increased over time, i.e. whether the expenditure share has become more income-sensitive more recently. This would signify that households in municipalities with higher incomes have increased their expenditure share for housing. Secondly, the regression in equation (7) gives us a direct estimate of the residual, $\varepsilon_{j,t}$, for each municipality j, and, based on the estimate for 2014, we can study whether the residuals are unusually high in a historical perspective. We do this by selecting the municipalities that have the 10 largest residuals in 2014, and then reporting these municipalities' residuals for earlier years (1995, 2000, etc.) as well. Thirdly, we are interested in the regression's explanatory power. A falling explanatory power would indicate that there is a more unexplained dispersion of expenditure shares between the municipalities.

31 We know prices continued to rise sharply in 2015, but the distribution among municipalities and the extent to which this was compensated for by a falling user cost and rising incomes is currently unclear.

Figure 10. Regression results on the municipal level per year



Regression result

	1995	2000	2005	2010	2014
Constant	0.26	0.22	0.14	0.11	0.18
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Slope-coefficient	0.84	1.1	0.76	0.47	0.77
	(0.06)	(0.07)	(0.05)	(0.03)	(0.05)
R^2	0.37	0.45	0.44	0.39	0.44

Note. Estimation results of equation (7) per year. Standard deviations in brackets.

Note. Own calculations as described in the main text around equation (7).
Sources: Aggregate earned income per muncipality and purchase price for houses (mean value in SEK thousands by region and type of property per year), Statistics Sweden; User cost, the Riksbank

Figure 10 gives a graphical representation of the observations for each year together with the regression line from equation (7). As we see from the various panels in the figure, relative income differences among the municipalities explain the differences in housing costs relatively well. This can be seen formally from the lower right-hand panel, which reports the regression results. From these results, we see that income differences explain almost half of the dispersion in the expenditure shares. We also see that the explained share is stable; there is no tendency for it to decrease over time.

It is also clear from the regression results and the figures that the housing expenditure share, *HES*, is strongly dependent on the income in the municipality. Apart from a dip in 2010, this elasticity tends to be around 0.8. Strictly interpreted, this means that households in a municipality with 30-per cent higher earned income compared to the average municipality spend almost 24 percentage points more of their income on housing. Even so, the income elasticity is probably overestimated for reasons discussed previously. This is due partly to the fact that we don't base our income series on those who have actually bought a house in the various municipalities, and partly to the fact that earned income excludes income from capital. Irrespective of this, the most interesting aspect is that the sensitivity in relation to earned income has not increased over time. There is therefore no support for the idea that HES has systematically become more income-sensitive recently. This means that the tendency towards greater dispersion in the expenditure share since 2010 – and hence in house prices as well – as we see in Figure 10, is largely explained by the slight increase in the income spread among municipalities.

Of course, this does not preclude the possibility that the expenditure share has increased by an unusually large amount in certain high-income metropolitan municipalities in recent years. To study this, we select the 10 municipalities with the largest positive residuals, i.e. the deviations from the straight line which we derive from the regression in equation (7) for 2014. Once we have selected the municipalities with the 10 largest deviations in 2014, we then study their deviations for all the previous years. This allows us to place the deviations for 2014 in a historical perspective, and to analyse whether the deviation in 2014 is unusually large from a historical perspective. Table 4 shows the results of this exercise. Panel A reports unexplained housing costs as a share of income for each year, i.e. $\varepsilon_{j,t}$ in equation (7), while Panel B reports the results in Swedish kronor (SEK), i.e. $\varepsilon_{j,t} \times y_{j,t}$.

Table 4. Municipalities with the most positive unexplained housing expenditure share in 2014 according to regression (7)

Panel A: Unexplained housing costs as a share of earned income

Municipality	2014*	2013	2010	2005	2000	1995
Malmö	0.41	0.36	0.30	0.37	0.45	0.30
Solna	0.40	0.29	0.24	0.34	0.58	0.31
Lidingö	0.38	0.31	0.18	0.18	0.40	0.33
Sundbyberg	0.30	0.28	0.23	0.23	0.46	0.28
Danderyd	0.29	0.24	0.11	0.12	0.35	0.42
Göteborg	0.25	0.22	0.18	0.22	0.29	0.27
Båstad	0.24	0.14	0.13	0.16	0.26	0.24
Botkyrka	0.23	0.20	0.13	0.16	0.18	0.11
Stockholm	0.23	0.19	0.13	0.19	0.29	0.22
Strömstad	0.21	0.17	0.12	0.10	0.13	0.10

Panel B: Unexplained housing costs in SEK (real)

Municipality	2014*	2013	2010	2005	2000	1995
Malmö	83,445	72,877	56,454	70,764	80,749	48,125
Solna	117,712	81,828	62,920	82,865	130,065	58,356
Lidingö	119,996	94,261	53,133	49,468	102,162	70,817
Sundbyberg	82,673	76,021	59,057	56,380	105,367	52,749
Danderyd	97,624	80,006	34,544	36,663	94,296	94,562
Göteborg	63,309	52,846	40,335	48,396	58,410	46,924
Båstad	56,132	32,579	29,365	34,094	49,788	38,848
Botkyrka	53,540	44,678	28,804	33,602	35,739	19,698
Stockholm	64,875	52,590	34,325	46,331	64,218	39,974
Strömstad	47,002	37,543	26,485	21,393	23,323	15,502

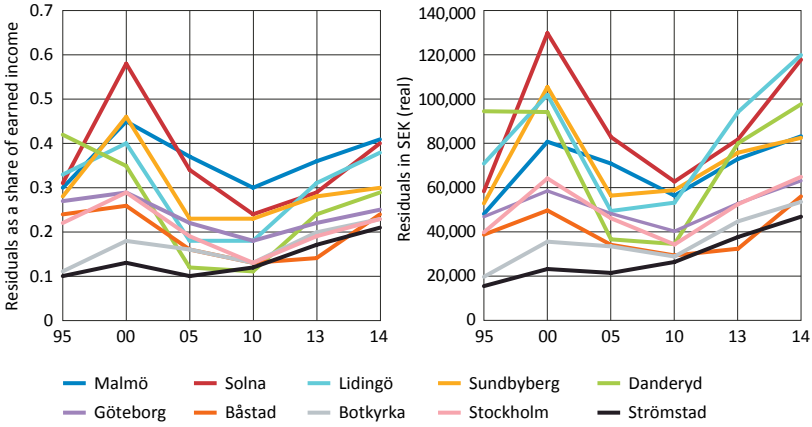
Note. * indicates that we have selected municipalities with the largest positive unexplained expenditure share in 2014, i.e. $\varepsilon_{j,2014}$. For the other years, we report the unexplained variation in the expenditure shares for the same municipalities. In Panel B, we multiply the unexplained share by the real earned income, to obtain the unexplained variation in user cost in SEK (in real terms).

As is clear from the results in Table 4, all the municipalities with the largest share of unexplained HES are metropolitan municipalities, with the exception of Båstad and Strömstad, two very attractive holiday resorts on Sweden's west coast. Malmö is the municipality with the largest unexplained share of HES. In Table 3 we could see that households in Malmö spend 45 per cent of their earned income on housing, while the average for the country as a whole is 16 per cent. This is a difference of 29 percentage points. How is it then that we report a residual of 41 percentage points for Malmö in Table 4? Well, households in Malmö have 17 per cent lower earned income than the average household in the country as a whole (SEK 205,788 compared to SEK 243,829). Our regression then implies, according to the table in Figure 10, that households in Malmö should spend 0.18 + 0.77 = 0.04, i.e. only 4 percentage points of their earned income on housing. In reality, however, they spend 45 percentage points, i.e. 41 percentage points more than they should according to normal patterns for all municipalities for our linear regression specification. Correspondingly for Danderyd, the municipality with the second largest HES of 72 percentage points, the residual is only 29 per cent since household earned income there is 34 per cent higher than in the country as a whole. We can use similar reasoning to explain the figures for the other municipalities in Table 4.

It is reasonable to think that omitted factors like urbanisation and problems in increasing the supply of housing to meet the increase demand are the underlying causes of the high proportion of unexplained variation in these municipalities. Even so, it is worth noting that our analysis indicates that the unexplained variation in HES at the end of 2014 is not unusual from a historical perspective in these municipalities. As is evident from Table 4, the proportion of unexplained variation was just as large as during the second half of the 1990s. If anything, it seems possible to make a case that the house valuations in several of these municipalities were unusually low in 2005-2010 given the fall in the user cost, and that prices have now caught up with the falling user cost.

Figure 11 documents the development over time of the residuals from Table 4. The figure confirms that the increase in residuals from 2010 to 2014 (and also 2013-2014) is substantial for several municipalities. But in terms of levels, the residuals for the studied municipalities are close to what they were in 2000. A tentative interpretation of this is that omitted variables and measurement issues cause municipalities to differ in the long term in a way that makes the housing costs deviate from equation (7). As mentioned above, there are many possible reasons why the simple linear reqression in equation (7) does not perfectly capture the relationship between housing costs and earned income.

Figure 11. Development over time of the unexplained housing expenditure share in the top-10 municipalities in 2014



The figure also shows the substantial covariation among the municipalities. This is due to the fact that the user cost, uc_t, is common for all municipalities. This should actually be captured by our regression model in equation (7), but this does not happen in our simple linear approach. In this context, it is worth noting that a linear-quadratic model fits the data better than our linear approach.[32] This reflects that HES in high-income municipalities generally seems to be more income-sensitive than in low-income municipalities, and this increased income sensitivity is captured better in a linear-quadratic model than in our linear model. It is important to realise, however, that although the data fit is significantly better with a linear-quadratic model, it does not affect the conclusion that the residuals tend to be greatest in metropolitan areas. Nor does it affect the conclusion that the residuals have not increased noticeably since the end of the 1990s.[33]

32 In a linear-quadratic approach, the model's explanatory power increases to as much as 0.46, 0.52, 0.47 and 0.43 and 0.49 for 1995, 2000, 2005, 2010 and 2014. These are significantly higher coefficients of determination compared to the linear model, whose coefficients of determination are reported in Figure 10. Another advantage of the linear-quadratic approach is that low-income municipalities, such as Malmö in the example above, are not given such a low predicted expenditure share. An alternative to a more advanced econometric specification in order to increase the explanatory power is to include more explanatory variables, e.g. number of people moving into the area, new construction and associated costs, see the IMF's (2016) study of regional house price differences in Denmark.

33 These is one exception, however, and that is Danderyd: Households in Danderyd have a much higher earned income than households in other municipalities in 2014 (34 per cent higher), which, according to a linear-quadratic approach results in a much higher expenditure share and knocks Danderyd off the top-10 list.

4 Conclusions

In this article, we have studied the development of house prices in Sweden since 1990 and related it to international developments. Taken together, fundamental factors seem to be able to explain the high valuation for the country as a whole.[34] Compared with the other countries in the study, we note that Sweden has seen a strong increase in disposable income and financial net wealth along with a low level of housing investment. Together with substantial population growth and low real interest rates in recent years, these factors have contributed to the sharp increase in house prices during the period 1995-2015 in Sweden. But for several other countries, such as Denmark, Norway and the UK, the recent upturn in house prices can only be fully explained if we include increased household indebtedness. This indicates that imbalances may have accumulated on the housing markets of these countries.[35] The exception is Germany, where our results indicate that house prices may be considerably undervalued.

We have also studied the price development on the municipal level in Sweden to see if obvious imbalances have built up locally. We have focused particularly on municipalities that, compared with others, had unusually high housing costs in relation to earned income in 2014.[36] Unsurprisingly, we found that most of these are metropolitan municipalities. Even so, by calculating the housing expenditure shares for the municipalities back to 1995, we found that this relationship was not new – these municipalities have had a higher housing expenditure share compared with the average municipality for a long time.

It is important to note that we have only studied the pricing of houses (single-family dwellings), and therefore cannot say anything about the pricing of tenant-owned apartments. According to Valueguard's price index, which is only available from 2005 and onwards, prices of apartments have increased twice as fast as house prices in the country between January 2005 and 2015, an increase of 138 per cent compared with 71 per cent in nominal terms.[37] As house prices according to our study have risen well in line with fundamental factors, it can be reasonably assumed that prices of apartments in Sweden have increased more than historical patterns. In all likelihood, this reflects even greater limitations in the supply of apartments in the metropolitan areas and an increased preference for living in

34 Thus, we reach a somewhat different conclusion than some earlier studies, for instance the European Commission (2016). The main reason is that out methodology allows for more economic explanatory variables in addition to income (notably, the real interest rate) to affect the "fundamental" value of houses.

35 The UK stands out in this context. This might be explained by the fact that several international investors have invested in properties in the UK in general, and in London in particular, see Valentine (2015).

36 Data for 2015 and 2016 are not yet available.

37 Please note also that this discrepancy is not driven by geography: even if we only look at the Stockholm region, the increase in the prices of tenant-owned homes has been twice as high as for houses.

large cities among households. More studies are needed here. It would also be of interest to increase the number of countries in our panel (e.g. Australia, Belgium, Canada, France, Ireland, Italy, The Netherlands and Spain) to see whether our findings are robust when a larger number of countries is included.

According to the methods we have used, there is no evident overvaluation of houses in Sweden, either in the country as a whole or in the municipalities for which we have data. Perhaps surprisingly, is seems possible to explain the increase that has occurred by common macroeconomic variables. It is of key importance, however, to realise that the high valuation of Swedish houses is only sustainable in the long term if real interest rates remain low for the foreseeable future. It the economy experienced an unexpected, sharp and permanent increase in the real interest rate, for example as the result of an international banking crisis with significant contagion effects on Swedish banks, there is a risk of a rapid downward correction in house prices. The risk of this correction being large and difficult to handle from a stabilisation policy point of view increases if households expect real interest rates to remain low for the foreseeable future and therefore tend to take out large mortgages to finance their expensive housing purchases. There may therefore be reason to be concerned about developments on the Swedish housing market, and, as we see it, also good reason to limit further increases in household indebtedness until the effects of the global financial crisis subside and we can observe whether interest rates remain permanently low.

Most of today's housing policy debate in Sweden concerns reducing household demand for housing by limiting their ability to take out a mortgage, introducing amortisation requirements, and making house purchases more expensive by reducing the tax relief on interest expenditure and increasing the property tax. We believe that such measures, properly sized to take initial conditions of high debt levels and constraints on monetary policy accommodation into account, can be important in the near term. Even so, more beneficial effects on the economy as a whole can be achieved in the longer term if prices can be held back by satisfying the demand for houses by an increase in the effective supply, something which the International Monetary Fund emphasised in its Article IV Report for Sweden 2015 (see IMF, 2015). It is therefore of grave importance that the responsible politicians roll up their sleeves and sit down at the table to work on resolving the fundamental housing supply problems highlighted by Emanuelsson (2015) in his article.

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APPENDIX A – Data sources and transformations

Below we describe data sources and the transformations we have performed on the data used in Section 2. We present the data per country in alphabetical order.

Denmark

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	Danmarks Nationalbank	Nominal residential investment (N.111) divided by nominal GDP (B.1*g). In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	Danmarks Nationalbank	Nominal mortgage rate (30 years) minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	Danmarks Nationalbank	Household indebtedness (nominal) as a share of nominal disposable income. Percentage points.
Net wealth	OMXC20; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the OMXC20 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

Finland

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	Statistics Finland	Nominal residential investment (P51/ N1111+N1112) divided by nominal GDP (B1GMHT). In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	Bank of Finland; Statistics Finland	Weighted nominal mortgage rate (all maturities) minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	Bank of Finland; Statistics Finland	Household indebtedness (nominal) as a share of nominal disposable income. Percentage points.
Net wealth	OMXH25; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the OMXH25 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

Norway

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	SSB	Nominal residential investment divided by nominal GDP (whole economy). In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	SSB	Weighted nominal mortgage rate (applies to banks up until 2007, banks and credit companies thereafter) minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	SSB; Norges Bank	Household indebtedness (nominal) as a share of nominal disposable income. Percentage points.
Net wealth	Oslo Børs; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the OMXO20 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

UK

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	Bank of England	Nominal residential investment (Sector S.1, Asset AN.111) divided by nominal GDP. In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	Bank of England	Nominal mortgage rate (2 years, 75% LTV fixed interest) minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	Office for National Statistics, Bank of England	Household indebtedness (nominal) as a share of nominal disposable income. Percentage points.
Net wealth	Google Finance; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the FTSE100 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

Sweden

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	Statistics Sweden, the Riksbank; OECD	Real residential investment divided by real GDP (NR0103CE) up to 1992. The remaining data is from the OECD in nominal terms. In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPIF.
Real mortgage rate	Statistics Sweden, the Riksbank	Weighted nominal mortgage rate (all maturities) minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	Statistics Sweden, the Riksbank	Household indebtedness (nominal) as a share of nominal disposable income. Percentage points.
Net wealth	OMX30; OECD	Total household wealth minus their debt (nominally) divided by the CPIF, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the OMX30 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

Germany

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	OECD	Nominal residential investment divided by nominal GDP. In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	Deutsche Bundesbank	Weighted nominal mortgage rate minus inflation (calculated as above).
Population growth	EUROSTAT	Based on annual data on the population level, we estimate a quarterly series via a cubic spline. The population growth is then calculated as the logarithm of the fourth differential for the quarterly series. Percentage points.
Debt-to-income ratio	BIS; The Riksbank (DORIS); Bundesbank	Household indebtedness as a percentage of GDP (BIS total credit statistics, Q:DE:H:A:M:770:A) multiplied by nominal GDP and then divided by nominal disposable income from Bundesbank. Percentage points.
Net wealth	Google Finance; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the DAX stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

US

Variable	Source	Description
House prices	Dallas FED	Seasonally adjusted real house price index (RHPI), normalised to 1 1990Q1.
Disposable income	Dallas FED	Seasonally adjusted real disposable income index (RPDI), normalised to 1 1990Q1.
Residential investment	FRED database; OECD	Nominal residential investment divided by nominal GDP. Data from 1990Q1 up to and including 1994Q4 comes from a cubic spline of annual data from FRED (A011RE1A156NBEA). The rest is from the OECD. In percentage points.
Inflation	The Riksbank (DORIS)	Annual inflation in percentage points, i.e. 100 multiplied by the logarithm of the fourth differential for the seasonally adjusted CPI.
Real mortgage rate	FRED database	Nominal mortgage rate (30 years, MORTGAGE30US) minus inflation (calculated as above).
Population growth	FRED database	Based on quarterly data on the population level, population growth is calculated as the logarithm of the fourth differential. Percentage points.
Debt-to-income ratio	FRED database	Household indebtedness (CMDEBT) as a share of nominal disposable income (DPI). Percentage points.
Net wealth	Google Finance; OECD	Total household wealth minus their debt (nominally) divided by the CPI, normalised to 1 1990Q1. Since the OECD only has annual data for 1995-2015, quarterly data is generated by splining out the series with the S&P 500 stockmarket price index (ultimo) which is available at a quarterly frequency 1990-2015.

APPENDIX B – Model without net wealth

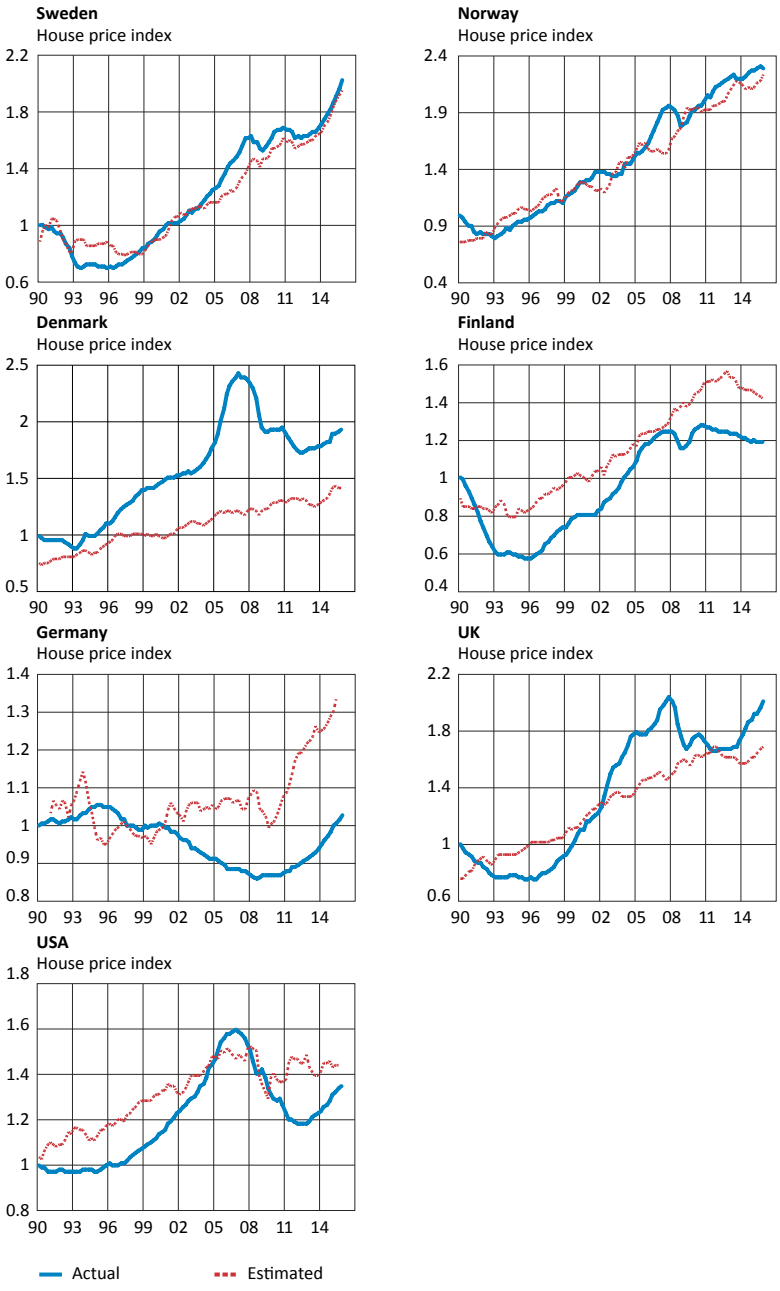
This appendix presents estimation results for the model without net wealth. Table B.1 presents the estimation results; the left-hand column excludes household indebtedness as an explanatory variable, while the right-hand column presents results when indebtedness is included as an explanatory variable. Compared with Table 1, the results in terms of parameter estimates are relatively stable. The coefficient for the debt-to-income ratio is virtually unchanged. We also see that the regression that includes household indebtedness as a dependent variable explains the variation in the data, both in total and for individual countries, much better.

Figures B.1 and B.2 show the actual and predicted house prices according to the models in Table B.1. We see that the actual prices, as far as Sweden is concerned at the end of 2015, are well in line with what the estimated models predict, which means that even if net wealth is excluded as an explanatory variable, there is no obvious overvaluation of house prices for the country as a whole.

Table B.1. Regression results for panel models of house prices, without net wealth

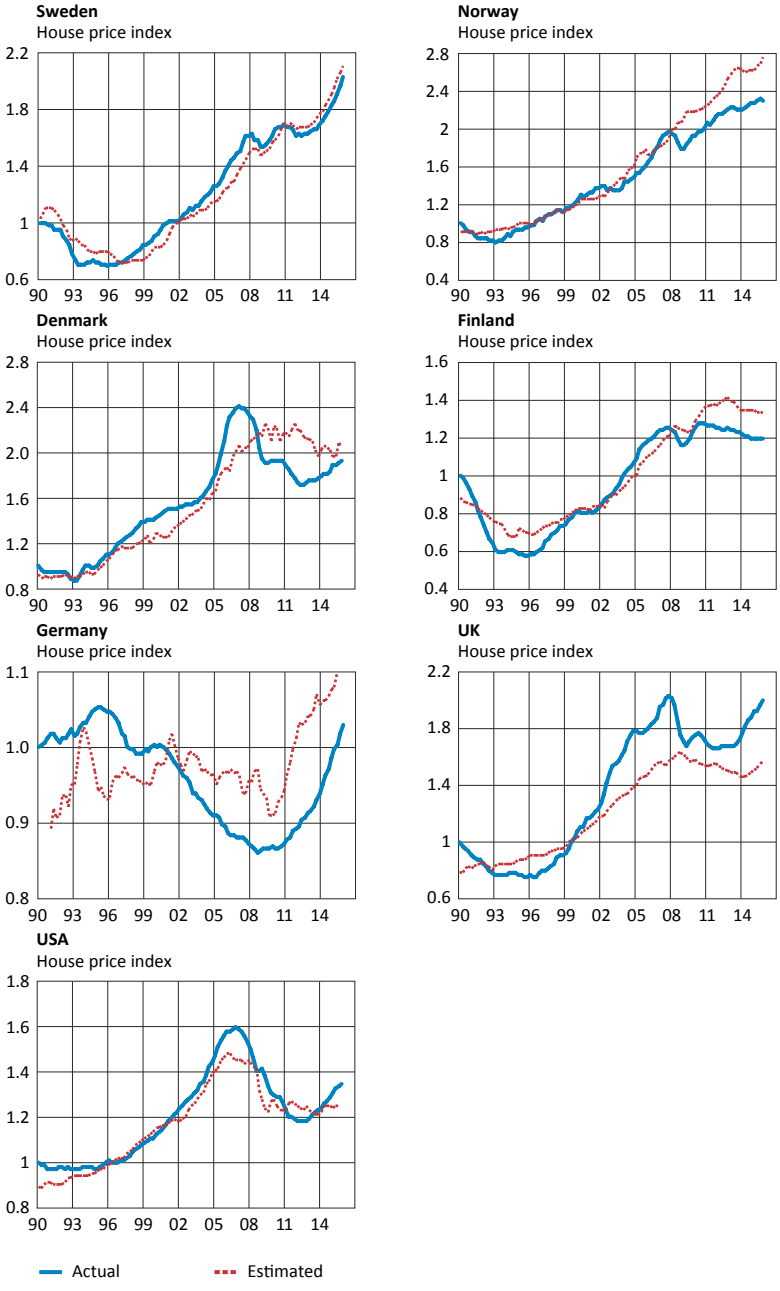
	Model without debt-to-income ratio			Model with debt-to-income ratio		
Variable	**Coeff.**	**Std. Dev.**	**p-val**	**Coeff.**	**Std. Dev.**	**p-val**
Disposable income	1.00	--	--	1.02	0.04	0.0000
Residential investment	1.58	0.57	0.0058	3.09	0.29	0.0000
Real mortgage rate	-2.54	0.31	0.0000	-0.78	0.22	0.0005
Inflation	-0.32	0.54	0.5603	0.68	0.29	0.0206
Population growth	23.77	2.20	0.0000	18.05	1.25	0.0000
Debt-to-income ratio	--	--	--	0.34	0.01	0.0000
Models' explanatory power - R^2_{adj}						
	Model without debt-to-income ratio			**Model with debt-to-income ratio**		
Total	**0.63**			**0.91**		
Individual countries						
Denmark	-0.65			0.84		
Finland	0.36			0.86		
Norway	0.92			0.92		
UK	0.76			0.82		
Sweden	0.91			0.93		
Germany	-5.02			-0.59		
US	0.33			0.90		

Figure B.1. Actual and estimated house prices from the regression model without net wealth and indebtedness



Note. The estimated prices (dashed red lines) have been calculated using the estimated coefficients reported in the left-hand column in Table B.1.

Figure B.2. Actual and estimated house prices from the regression model without net wealth but with indebtedness included



Note. The estimated prices (dashed red lines) have been calculated using the estimated coefficients reported in the right-hand column in Table B.1.

Macroeconomic effects of reducing household debt

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The Riksbank has for a long time emphasised that rising household debt is a concern for financial stability that needs to be addressed. Tighter macroprudential measures or tighter mortgage interest deduction are two alternative ways of tackling this problem. In this article, we study how these two approaches would affect different households using a macroeconomic model. We show that, contrary to what is often argued in the public debate, a tightening of the loan-to-value cap, the loan-to-income cap and the amortisation requirements would lead to a redistribution of resources from lenders to borrowers in the long-run. Moreover, tighter mortgage interest deduction affects households in different ways, depending on how the Government chooses to use the released budgetary resources. If borrowers are compensated, this policy could have positive effects for their consumption other than housing. We also analyse the implications for monetary policy of different measures to dampen household debt and show that the extent of mobility on the housing market plays an important role. In some cases, monetary policy might need to be more expansionary, and in other cases more contractionary. Finally, we study how household debt affects the transmission mechanism of monetary policy on inflation. The higher the indebtedness, the greater the effects of a rate hike on the interest expense and disposable income of borrowers. The effects of a rate hike on demand – and hence on inflation – are therefore greater today than when the inflation target was introduced in the mid-1990s.

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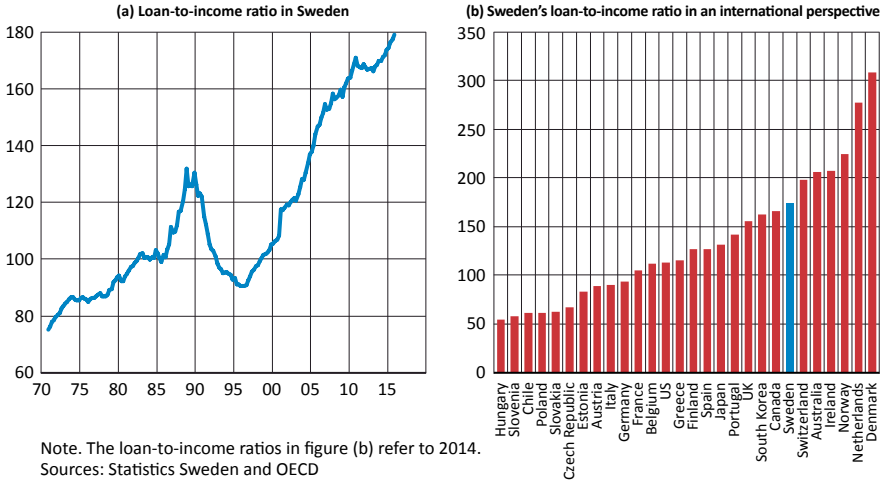
1 Why is it important to dampen household debt?

In the past 20 years, household debt has rapidly increased in Sweden. Over the period 1995-2015, household debt in relation to disposable income – the loan-to-income ratio – increased from around 90 per cent to close to 180 per cent, see Figure 1a. When only taking into account households with mortgages, the loan-to-income ratio is currently even higher, at around 320 per cent. Swedish household debt is not just high in a historical perspective, but also in an international comparison. The loan-to-income ratio of Swedish households is among the highest in the OECD countries, see Figure 1b.

The increase in indebtedness has been coupled with increasing house prices, see Figure 2a. In the past 20 years, prices have almost quadrupled. Several factors could explain such an increase. For example, relatively few homes have been built in the past few decades; moreover, the homes that do exist are perhaps not being used efficiently due to rental market regulations.[1] But the prices might also have been pushed up by the increase in households' disposable income, while interest rates have been low at the same time. The interest-to-income ratio of households – their interest expense in relation to their disposable income – is currently at its lowest level in around 40 years, see Figure 2b.

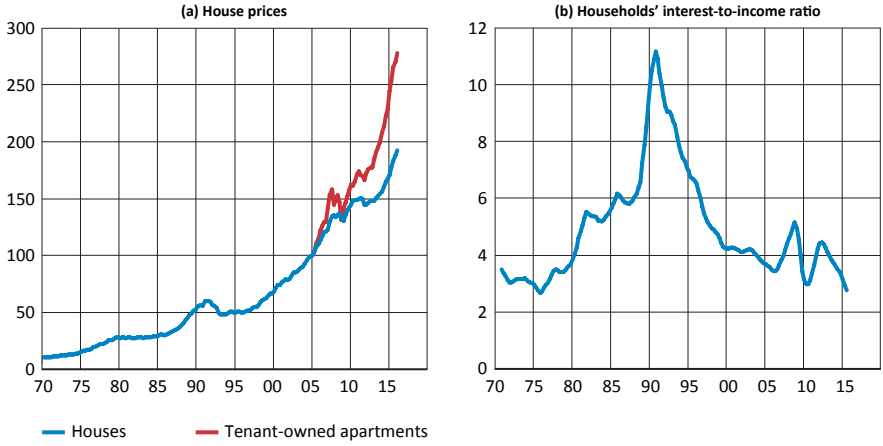
Figure 1. Households' loan-to-income ratio in Sweden and in an international perspective
Per cent of disposable income



Note. The loan-to-income ratios in figure (b) refer to 2014.
Sources: Statistics Sweden and OECD

1 See Emanuelsson (2015).

Figure 2. House prices and the interest-to-income ratio of households
Index 2005 = 100 and percentage of disposable income



Note. House prices refer to the house price index (private houses). Interest expense in the interest-to-income ratios is calculated after tax.
Sources: Statistics Sweden, Valueguard and the Riksbank

There are numerous cross-country examples showing that if household debt increases rapidly together with rises in house prices, vulnerability in the financial system, i.e. the risk of a financial crisis, increases. In many of the countries hit hardest by the global financial crisis of 2008-2009, the crisis was preceded by rapidly increasing debts and house prices. Moreover, the post-crisis slump risks to be deeper and more protracted if debts have been rising rapidly prior to the crisis.[2]

The most recent global financial crisis has also taught us that to monitor individual financial institutions, i.e. microprudential policy, is not enough; the functional capacity of the financial system as a whole, i.e. its exposure to systemic risk, must also be taken into account. This so-called macroprudential policy is a relatively new policy area that came into focus after the financial crisis to address systemic risk concerns. The purpose of macroprudential policy is both to maintain the resilience of the financial system, and to counteract risks.

The European Systemic Risk Board, ESRB, issues recommendations regarding macroprudential targets and specific measures in Sweden and other EU countries. According to ESRB, an intermediate target of macroprudential policy is to avoid excessively rapid credit expansion and high loan-to-income ratios.[3] In line

2 See Emanuelsson et al. (2015) for an overview of empirical studies of financial risks linked to household indebtedness.

3 The other targets pertain to differences in maturities between liabilities and assets, concentrated exposures and misguided incentives for large institutions linked to the implicit or explicit public guarantees.

with this, the Riksbank has long been emphasising that rising household debt is problematic, and that the associated risks need to be addressed. Potential measures mentioned in the policy debate to deal with these risks include tightening the loan-to-value cap, introducing a loan-to-income cap, introducing an amortisation requirement, or tightening the mortgage interest deduction, i.e. reducing the tax relief on mortgage interest.[4]

The first three measures are examples of macroprudential tools that might be expected to dampen household demand for credit. The loan-to-value cap limits the size of the mortgage that may be granted to a household in relation to how much the home is worth. It therefore has a direct impact on how much debt a household may take. A loan-to-income cap also limits the size of the loan, but in relation to the borrower's income rather than the value of the home. The amortisation requirement potentially restricts the possibilities of households to take out loans. In particular, it poses a limitation for households that meet the down payment requirements, but which might have difficulty in saving further amounts in the first couple of years of the duration of the loan.

The tax relief on mortgage interest is a fiscal policy measure. Indebted households can currently deduct 30 per cent of their interest expense from their total tax, up to SEK 100,000. This mortgage subsidy incentivises households to take out larger mortgages than they would have done without the tax relief. If the tax relief on mortgage interest were reduced, it is therefore probable that households' demand for mortgages would decrease, and it would thus be an effective measure for curbing the build-up of debt.

2 Summary of our findings

In this article we study how different households are affected and what the macroeconomic consequences would be from tightening the loan-to-value cap, the loan-to-income cap and the amortisation requirements, and reducing the tax relief on mortgage interest. In our policy experiments, we use a macroeconomic model fitted to Swedish data.

We find that all the macroprudential measures considered in our study curtail indebtedness in the economy over time; this in turn brings about a reduction in both the interest expense of borrowers and the interest income of lenders. These measures lead to a redistribution of resources from debt-free to indebted households, i.e. from lenders to borrowers. Lenders will reduce their consumption of goods, housing services and leisure, since their interest income will be lower. On the other hand, borrowers can increase consumption of goods and leisure.

4 See e.g. Sveriges Riksbank (2014, 2015 and 2016).

Whether or not they also increase their consumption of housing services depends on which measure is undertaken. A tighter loan-to-value cap will force borrowers to cut back on their consumption of housing services. While, if the amortisation requirement and loan-to-income cap are tightened, borrowers will also consume more housing services.

A reduction in the tax relief on mortgage interest leads in the long-run to a redistribution of the consumption of housing services from borrowers to lenders. However, if the Government uses the released budgetary resources to compensate borrowers, they can increase their consumption of goods and leisure.

The tightening of various macroprudential measures and the reduction of the tax relief on mortgage interest can also have short-term effects on demand and inflation. The central bank may need to consider this when setting the policy rate. How monetary policy reacts to lower household debt depends both on the measure underlying the reduction, and on residential mobility. If mobility in the housing market is relatively low, households will cut back on non-durables consumption, thereby dampening demand and hence inflation. In such a scenario, monetary policy may need to be more expansionary. If, however, the mobility in the housing market is relatively high, monetary policy may instead need to be tighter.

We also study how the level of household debt affects the impact of monetary policy on inflation and household consumption. A high degree of indebtedness makes borrowers more sensitive to changes in interest rates. The higher the indebtedness, the greater the effect of, for instance, a rate hike on borrowers' interest expense and disposable income, which in turn reduces their scope for consumption. This means that the effect on demand, and hence on inflation, from an increase to the policy rate would be higher today than previously. Specifically, a rate hike at the current level of indebtedness reduces borrowers' consumption much more than it would have done had indebtedness been at the same level as when the inflation target was introduced in the mid-1990s. The effect on inflation from this rate hike is thus also greater today than in the mid-1990s.

The paper is structured as follows. In the next section, we present the macroeconomic model used in our policy experiments, and in the section after that we describe how the model has been fitted to Swedish data. Following that is a section showing the long-term macroeconomic effects of the alternative measures. We then discuss the short-term effects of deleveraging on inflation and the policy rate, and how the potency of monetary policy is affected by the level of household debt. Finally, we compare our findings with other studies on household debt.

3 The economic environment

This section presents the macroeconomic model we use in our policy experiments.[5] Figure 3 illustrates the structure of the model. The economy is populated by households, corporations, banks, a central bank and a fiscal authority. For the sake of simplicity, we disregard foreign trade and cross-border financial flows in the analysis.

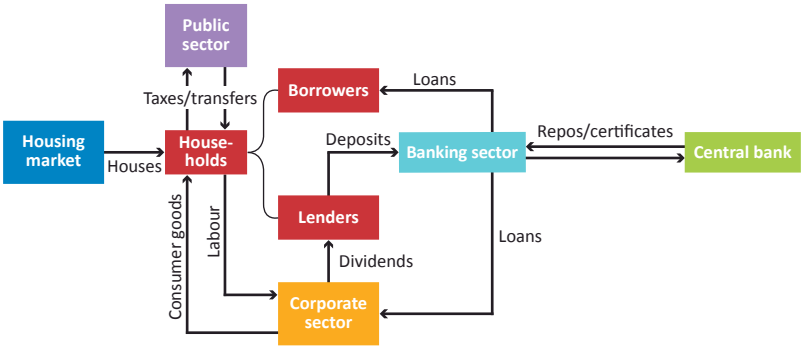
The housing market is an important part of the model since the measures we study have a direct effect on the households' demand for housing. A simplifying assumption is that housing is in fixed supply. Households buy and sell housing services to a market determined price.[6] Furthermore, it is assumed that there are only two categories of households – "lenders" and "borrowers", who differ in the way they discount future consumption. Lenders save in bank accounts and finance their housing investments without a mortgage. On the other hand, borrowers finance primarily their housing investments with bank loans. In addition to these two categories of households, there are also "entrepreneurs" who take out bank loans to finance their investments.

Banks have two sources of funding, equity and households' deposit and can use a deposit facility at the central bank. The interbank rate is thus affected by the policy rate set by the central bank. It is assumed that different banks can offer slightly differentiated financial product, i.e. they operate under "monopolistic competition". The degree of their monopoly power determines over time the spreads between the central bank's policy rate and the banks' rates for households and corporations. In the short-term, these spreads will also be affected by the fact that banks are subject to adjustment costs when changing the interest rates. Household preferences are described by a utility function, which depends on their consumption of goods, housing services and leisure. Both categories of households are forward-looking, but they attach different weights to their expected future utility. The lenders are assumed to be more "patient" and care more about future consumption than borrowers do; this leads the lenders to save more.

5 The model is based on Gerali et al. (2010), which provides a more detailed description. However, we have modified their model on some key points, in order to study the effects of amortisation requirements, a loan-to-income cap and reduced tax relief on mortgage interest. See Finocchiaro et al. (2016).

6 There are therefore no rented homes in this model. "Goods" refers to an aggregate of non-durable consumer goods and services other than housing services.

Figure 3. An overview of the model structure



Source: Own illustration

The lenders choose how much they will work, spend on consumer goods and housing investments, and how much they will deposit in the bank to maximise utility. Their disposable income consists of wage income, interest on their savings and transfers or taxes from the public sector, as well as dividends from companies. Borrowers are subject to similar budget restrictions but they can also finance their housing with mortgages. In our analysis, we are particularly interested in which terms and conditions, besides the lending rate level, apply for households to be granted these loans.

Households can increase or reduce their housing holdings by buying or selling on the housing market. The houses depreciate over time at a rate of δ_H so the household's housing holding at a certain point in time t, H_t, is determined by undepreciated housing $(1 - \delta_H)\, H_{t-1}$ and new housing investments I_t,

$$(1) \qquad H_t = (1 - \delta_H)\, H_{t-1} + I_t.$$

Note that we can break down the housing investments of the household into depreciations of the existing homes and changes in the housing stock. In the long-run, total housing investments consist of replacement investments, $\delta_H \bar{H}$, where $\bar{H}$ is the constant volume of houses.[7] The total volume of houses is in fixed supply. This implies that if, for example, the borrowers buy more housing services the lenders must consume less.

The model can be used to study the effects of changes in both the loan-to-value cap and in the loan-to-income cap. The loan restriction for the borrowing households differs in these two cases. When borrowing is constrained by a loan-

7 A dash over a variable denotes that it is a long-term value.

to-value cap, new loans of households, N, may not be greater than the share μ of the nominal value of housing investments,

(2) $$N_t \leq \mu Q_t I_t,$$

where Q is the nominal house price.[8] Aggregate household debt, B, is affected by households' amortisation of the existing debt ρB where the parameter ρ is the rate of amortisation.[9] Hence, indebtedness progresses according to the following relationship over time,

(3) $$B_t = (1 - \rho)B_{t-1} + N_t = (1 - \rho)\ B_{t-1} + \mu Q_t I_t.$$

In the second case, borrowing is limited by a loan-to-income cap. In that case, new loans may at most be a share σ of wage income,

(4) $$N_t \leq \sigma W_t L_t,$$

where W is the nominal hourly wage rate and L are the hours worked by the borrowing household.[10] In this case too, the households are assumed to amortise the loans at the rate of ρ. Household debt thus progresses according to

(5) $$B_t = (1 - \rho)B_{t-1} + N_t = (1 - \rho)B_{t-1} + \sigma W_t L_t.$$

The budget constraint of the borrowers is as follows:

(6) $$P_t C_t + Q_t I_t + (\rho + R^H_{t-1})\ B_{t-1} + T_t + A_t = W_t L_t + N_t + \omega^{RH} R^H_{t-1} B_{t-1}.$$

The left hand side shows expenditure, which besides purchases of consumer goods C at the price P and housing investments QI also consist of amortisation ρB and interest payments, $R^H B$ on the mortgage.[11] The households also pay lump-sum

8 The loan restriction in equation (2) thus limits the household's new loans in relation to the value of housing investments, which is an approach proposed by Kydland et al. (2016). An alternative formulation of the loan restriction is that the loan stock of households is limited by (the expected) value of the housing stock as in e.g. Iacoviello (2005). This entails however that all loans are short (one period) and that the aggregate loan stock of households is directly affected by the development of house prices.

9 The "impatience" of the borrowers is considered to be so great that they always borrow up to the limit, i.e. the restriction in equation (2) is always binding. The same assumption is made for the restriction in equation (4).

10 The fact that the new loans N are limited by income from salary also implies that total loans, B, are limited. In the model calibration, the parameter σ is set so that the total debts of the borrowing households in relation to annual income, $\sigma / 4\rho$, has a reasonable value, see more below.

11 All interest rates in the model are floating (one period), so the households pay the same interest rate irrespective of when the loan was granted.

taxes T and adjustment costs A that arise when households change their housing investments.[12] These costs aim at capturing, in a simplified way, the effects of various factors that affect mobility on the housing market. The right hand side of the budget constraint shows the resources available to finance expenditures. Besides labour income WL the resources consist of new bank loans N (which are limited by equation (2) or equation (4)) and of government subsidies of the households' mortgage expenses $\omega^{RH} R^{H} B$. The degree of the subsidy is given by ω^{RH}. Another way of reducing household debt – besides limiting the loan-to-value ratio μ and/or the loan-to-income ratio σ or imposing demands for a higher amortisation rate ρ – is thus to reduce this subsidy.

In order to finance public consumption and mortgage interest subsidies, the public sector balances its budget by levying lump-sum taxes from the households, and a tax on the dividends that the lenders receive from the corporate sector. Government consumption is assumed to make up a constant share of GDP, while the lump-sum tax is distributed between the lenders and the borrowers in relation to their shares of the total wage sum.

The objective of monetary policy in Sweden is to maintain price stability, while at the same time monetary policy shall contribute to sustainable growth and a high level of employment. In the model, it is assumed that the central bank can adjust its policy rate R to stabilise both inflation π and GDP growth ΔY in the economy. Inflation is defined as the annual percentage change in the price of the consumer goods P. More specifically, the policy rate evolves according to,

$$R_t = \phi_R R_{t-1} + (1 - \phi_R)[\bar{R} + \phi_\pi (\pi_t - \bar{\pi}) + \phi_Y \Delta Y_t] + \varepsilon_t, \tag{7}$$

where $\bar{R}$ is the long-term level of the policy rate, $\bar{\pi}$ is the long-term level of the inflation rate (which coincides with the central bank's inflation target) and ε a disturbance term that we use to capture the non-systematic (unexpected) component of monetary policy. The parameter ϕ_R is a measure of the inertia in setting the interest rate, while ϕ_π and ϕ_Y measure how much the central bank's choice of policy rate level is affected by inflation and growth fluctuations, respectively. In the long-run, monetary policy does not affect the rest of the economy. In the short term, however, the macroprudential and fiscal measures in our study may have an impact on demand and inflation, to which monetary policy may need to react.

Lower loan-to-value or loan-to-income caps, stricter amortisation requirements and reduced tax relief on mortgage interest are all examples of

12 Lump-sum taxes means that the households pay a fixed amount in tax. The households' behaviour therefore does not affect the size of the tax payment.

alternative measures that have emerged in the Swedish debate as potential solutions for counteracting the risks associated to high indebtedness. In the model, changes to the parameters μ (loan-to-value cap), σ (loan-to-income cap), ρ (amortisation requirement) and ω^{RH} (tax relief on mortgage interest) correspond to these measures.

4 Fitting the model to Swedish data

In order to study the macroeconomic effects of reducing Swedish household debt, the model must be fitted to Swedish data. In other words, the model parameters much be assigned values so that the characteristics of the model reflect the Swedish economy. The parameters can be divided into two categories.

The first category consists of parameters that primarily affect the model's long-term characteristics. For those parameters, there is often an observable equivalent in data. An example is the parameter that determines the degree of competition on the mortgage market, which in turn determines the banks' average margins on mortgages. This parameter can be determined based on the average difference between mortgage rates and the repo rate. In Table 1 we describe long-term levels for certain variables in the model that are of particular importance. The aim is not to exactly match the long-term values with data, but rather to verify that the consistency is sufficiently good for the model to be used to study the effects of reducing household debt in Sweden.

The other category consists of parameters that primarily affect the short-term dynamics. An example of one such parameter is that which determines what impact a change to the repo rate will have on the mortgage rate. For these parameters, there is typically no observable equivalent in data, so other methods are needed to estimate them. We have used Bayesian econometrics to estimate them, entailing that we have combined information in data with judgements based on economic theory and empirics.

4.1 Household debt, loan-to-value ratio and amortisation

As we noted in the beginning of this article, the debt ratio of the Swedish households has increased from around 90 per cent in 1995 to close to 180 per cent in 2015. Around 75 per cent of those debts consist of loans collateralised by homes. Mortgages thus made up around 130 per cent of households' disposable income in 2015. The fact that this ratio has increased over the past 20 years makes it difficult to calibrate the debt ratio, because in the model it is constant in the long term. We have set the long-term ratio of mortgages to households' disposable income to 124 per cent, i.e. somewhat lower than the current level.

This ratio is mainly determined by how the households finance purchasing their homes, and how fast they pay down the loans. When the size of the loan is limited by how much the home is worth, the following relationship gives the loan-to-value ratio for the mortgage stock in the long term:

$$\mu_B = \frac{\mu\delta_H}{\rho}, \tag{8}$$

where μ_B is the loan-to-value ratio in the mortgage stock, μ is the loan-to-value ratio for new loans, δ_H is the rate of depreciation of the housing stock, and ρ is the amortisation rate. In the model, the loan-to-value ratio for new loans coincides with the loan-to-value cap, because the loan restriction is assumed to be binding and the borrowing households are identical. In reality, the loan-to-value ratio varies between households, and most households borrow below the loan-to-value cap. With the present level of the loan-to-value cap, the size of a loan collateralised by the home may amount to no more than 85 per cent of the value of the home. The average loan-to-value ratio for new loans was 72 per cent in 2014, while the loan-to-value ratio for the entire mortgage stock in the same year was 63 per cent.[13] Using microdata regarding household debts for 2013-2014, we can calculate the annual amortisation rate at around 2 per cent annually, more or less equalling an amortisation period of 50 years. Based thereon, we set μ_B = 65 per cent, μ = 75 per cent, and ρ = 0.7 per cent (quarterly).[14] The relationship above then gives a rate of depreciation of δ_H = 0.6 per cent (quarterly).

In order for the loan-to-income ratio in the model to be consistent with data, the borrowing households' share of the total wage sum is set to 40 per cent. Borrowers' mortgages in relation to disposable income will then be 456 per cent, which is in line with data. The average loan-to-income ratio for new loans was 387 per cent in 2014 and 406 per cent in 2015.[15] The volume-weighted average loan-to-income ratio was close to 500 per cent in 2014.

The loan-to-income cap limits how much households may borrow in relation to their wage income (see equation (4)).[16] In the model, $\sigma/4\rho$ corresponds to the ratio of mortgage debt to the borrowing households' wage income, and is set at 251 per cent. Whichever measure of income we use, a tightening of the loan-to-income cap will affect debts as a share of both the wage income and the disposable income. In our calculations below, we will describe how they are affected in relation to wage income.

13 For new loans, the volume-weighted average in Finansinspektionen's sample is used. See Finansinspektionen (2015).
14 With this amortisation rate, around half the value of a home will be amortised after 25 years.
15 See Finansinspektionen (2016).
16 The borrowing households' disposable income consists of wage income, less interest expenses and taxes.

4.2 Interest rates

The banks operate, to a certain degree, as monopolists. This creates a positive spread between their lending rates and the risk-free rate, while deposit rates are lower. The various spreads in the model are calibrated based on average deviations from the repo rate for the period 1995-2015. The average repo rate for that period was 2.7 per cent. The short mortgage rate was 4.0 per cent on average, the short corporate lending rate was 4.7 per cent, and the deposit rate 1.4 per cent.

4.3 The banking sector

The model describes a closed economy. The banks' assets and liabilities thus relate to domestic mortgages and corporate lending in the banks' balance sheets. Swedish mortgages make up around 15 per cent of the banks' assets, and lending to non-financial corporations makes up around 10 per cent of the assets. Hence, around one quarter of the Swedish banks' assets are covered by the model. The assets of the four large Swedish banks as a share of GDP are around 400 per cent, and they account for around three quarters of all deposits and lending in Sweden. We have therefore calibrated the banks' assets as a share of GDP to a value somewhat above 100 per cent. In the model, the banks' lending is only funded by household deposits and equity. In the data, deposits and borrowings from the general public make up around 35 per cent of the four large banks' funding.

The four large banks' equity in relation to their assets (leverage) varies in the range of 4 to 6 per cent. In the model, the leverage ratio of the banking sector is calibrated at 4.6 per cent. We also assume that the resources needed to run the banks, such as salaries for employees, depend on the size of the banks' capital. The banking sector's share of GDP is set at 3.6 per cent.

4.4 Tax relief on mortgage interest

The 30 per cent tax relief on mortgage interest equals 2.5 per cent of public expenditure in the model. In the model, the indebted households spend around 7.4 per cent of their gross income on interest payments. This is a relatively high percentage compared with recent data on the hosueholds' interest-to-income ratio and the difference may, at least partially, be explained by the fact that the interest rate in recent years has been much lower than its normal level.

Table 1. Calibration of long-term values in the model
Per cent

GDP components and tax relief on mortgage interest	Value
Consumption, percentage of GDP	49
Investments, percentage of GDP	22
Public expenditure, percentage of GDP	29
Tax relief on mortgage interest, percentage of public expenditure	2.5
Interest rates	
Repo rate	2.7
Mortgage rate, short	4.0
Corporate lending rate, short	4.7
Deposit rate, short	1.4
Debts, loan-to-value ratios and amortisation	
Mortgage debt, percentage of GDP	55
Mortgage debt, percentage of disposable income, all households	124
Mortgage debt, percentage of disposable income, indebted households	456
Mortgage debt, percentage of wage income, indebted households	251
Loan-to-value ratio, new loans	75
Loan-to-value ratio, mortgage stock	65
Amortisation, percentage of loan stock, by quarter	0.7

5 Long-term effects of reducing household debt

As discussed above, there are several different measures which Swedish authorities may undertake to dampen the increasing household debt. In this section we examine, from a macroeconomic perspective, what the long-term effects would be of four different measures:

- Tightening the loan-to-value cap
- Tightening the amortisation requirement
- Introducing a loan-to-income cap
- Reducing the tax relief on mortgage interest

We calculate how the different measures would affect households by applying each measure such that the borrowing households' loan-to-income ratio (the percentage of mortgage debt of income from salary) declines by 10 per cent. This implies that mortgage debt as a share of disposable income declines by around 12 percentage points. Such a standardisation will facilitate the comparison of the effects of the different measures.[17] We then calculate what the macroeconomic effects would be for the households. The level of the loan-to-income ratio can be seen as a measure of potential risks in household debt, because many households use their current income to pay their loan expenses.

5.1 Effects of tightening the loan-to-value cap

A loan-to-value cap means that the size of a mortgage is limited with respect to how much the home is worth. If the cap is tightened, households can thus finance a smaller proportion of their home purchases with loans. In Swedish data regarding loan-to-value ratios for new loans, there is a wide spread across households. Between 20 and 30 per cent of households are limited by the loan-to-value cap. In the model we assume that all borrowers have the same loan-to-value ratio for new loans μ. We also assume that the loan-to-value ratio of the households decreases if the loan-to-value cap is tightened. The loan restriction for the borrowing households (equation 2) can, in long-term equilibrium, be written as,

$$\frac{\bar{N}}{\bar{Q}\,\bar{I}} = \mu. \tag{9}$$

Similarly, the debt equation (equation 3) can be written as

$$\bar{N} = \rho\,\bar{B}, \tag{10}$$

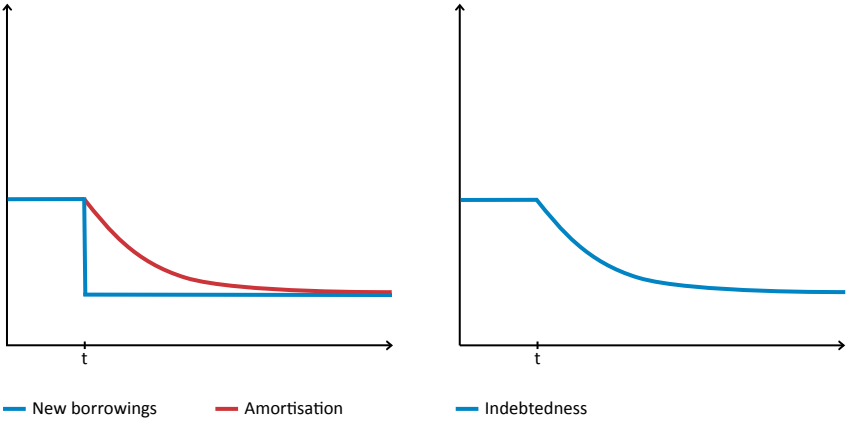
where the parameter ρ denotes the borrowers' amortisation rate and B their indebtedness. Hence, the new borrowing of households N equals their loan amortisation in the long run.

In the model, the mortgage rate over time is determined by two factors: the state of competition on the mortgage market, and households' preferences for consumption today in relation to consumption in the future. Changes to the loan-to-value cap therefore do not affect the mortgage rate, and neither do any of the other measures. That means, for example, that if the loan-to-value cap is tightened, the interest expense of borrowers will decrease – indebtedness will decline while the interest rate remains the same.

17 The measure thus leads to the borrowing households' mortgage debts as a percentage of wage income decreasing from 251 to 226 per cent.

Figure 4 shows how new borrowing, amortisation (ρB) and indebtedness change over time if the loan-to-value cap is tightened. The loan-to-value cap is reduced at the point in time t. We can see that new borrowings drop immediately, while amortisation and indebtedness slowly adapt to new, lower levels. In time, indebtedness decreases in the same proportion as new borrowing, because a tightened loan-to-value cap does not change the amortisation rate.

Figure 4. Adjustments of new borrowings, amortisation and indebtedness following a tightened loan-to-value cap
SEK



Source: Own illustration

In Table 2 the long-term effects for households from tightening the loan-to-value cap such that the loan-to-income ratio decreases by 10 per cent are shown. The average loan-to-value ratio for new loans then declines from 75 to 70 per cent. The borrowers use the funds released by the lower interest expense to increase consumption of goods (around 2 per cent) and leisure (around 1 per cent). But the tighter loan-to-value cap also brings about a reduction in the consumption of housing services of around 1.5 per cent.

In the model, the supply of homes is assumed to be constant, so only a redistribution of the housing stock between borrowers and lenders occurs. Because the borrowers cut down on their consumption of housing services, the lenders will increase their consumption to the same extent. In this case, the lenders' consumption of housing services increases by around 1 per cent.

For the lenders the lower loan-to-value cap leads to an increase in the consumption of housing services, while at the same time their savings decline

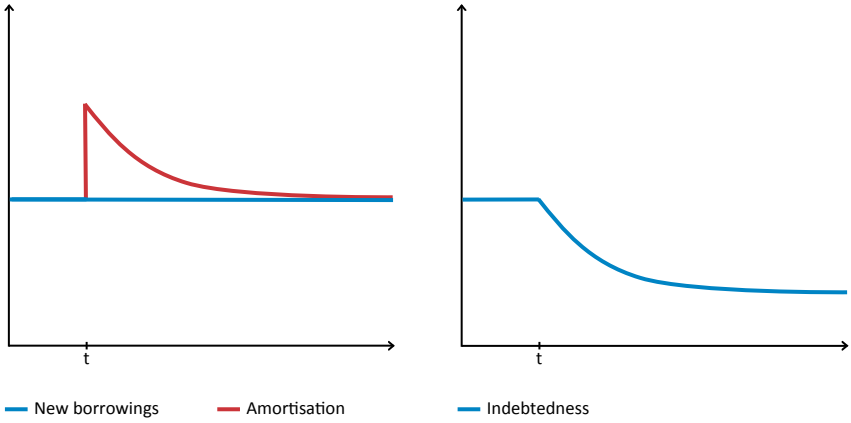
and hence their interest income too. Consequently, they increase labour supply somewhat and reduce their consumption of goods. The lower indebtedness in the economy thus brings about a shift in resources from lenders to borrowers.

5.2 Effects of increasing the amortisation rate

The purpose of an amortisation requirement is to make households amortise their debts faster. An increased amortisation rate will, like a lower loan-to-value cap, lead to debts decreasing and being lower in the new long-term equilibrium. However, the measures affect new borrowings in different ways, so the effects on households' consumption of goods and housing services will also be different with an increased amortisation rate ρ compared to with a lower loan-to-value cap. Assume that the amortisation requirement is tightened, leading to an increase in the amortisation rate . In that case, new borrowings and indebtedness will not change proportionally to each other, see equation (10). In the model, a faster amortisation rate leads to a decline in indebtedness, while new borrowings are largely unchanged both in the short and long term. The effect thus differs from a lower loan-to-value cap, which leads to new borrowings declining rapidly and being lower over time, because the loan-to-value cap directly limits new borrowings. An amortisation requirement does not have the same direct effect on new borrowings, and will therefore have less of an impact on the housing market. Figure 5 illustrates the effects after a tightening of the amortisation requirement at the point in time t. The increased amortisation rate leads to amortisations rising initially and being greater than new borrowings, to then fall back as indebtedness declines to a lower long-term level. In the long run, the size of amortisations ρB is more or less unchanged. The share of debt that is amortised each year ρ has increased but at the same time the debt B has decreased. Because new borrowings in time are affected in the same way as amortisations, this also means that new borrowings are largely unaffected over time.

This illustrates an important difference between tightening the amortisation requirement, and tightening the loan-to-value cap. Both measures lead to lower indebtedness over time, but a higher amortisation rate has little impact on new borrowings, while a lower loan-to-value cap leads to a drop in new borrowings in proportion to indebtedness. This is important because it is new borrowings, and not indebtedness, that affect the possibilities of borrowers to consume housing services.

Figure 5. Adjustments of new borrowings, amortisation and indebtedness following a tightened amortisation requirement
SEK



Source: Own illustration

Table 2 shows the quantitative effects of a tightening of the amortisation requirement. In order for the loan-to-income ratio to fall 10 per cent, the amortisation period must shorten from 50 to 45 years. New borrowings will be slightly lower in the long-term with this measure. The borrowing households use the money they have left over from reduced interest expense to consume goods and leisure, besides consuming slightly more housing services. The interest income of the lenders declines, because saving in the economy falls. Therefore, they cut down on the consumption of goods, housing services and leisure.

5.3 Effects of introducing a loan-to-income cap

The loan-to-income cap is a macroprudential measure that resembles the loan-to-value cap. The difference is that households' loans are not limited by the value of the home, but rather by the households' income from salary. Hence, the introduction of a loan-to-income cap leads to a change in households' new borrowings in relation to their indebtedness, just like after a tightening of the loan-to-value cap. However, unlike a tightening of the loan-to-value cap, a reduction in new borrowings due to a loan-to-income cap does not necessarily reduce borrowers' possibilities to consume more housing services, because new borrowings in this case are not linked to the value of the home.[18]

18 Formally, this means that the restriction in equation (2) is not binding. Even if new borrowings decline, the borrowing households' consumption of housing services can be unchanged or even increase because their interest expense decreases, as long as they meet the budget restriction (6).

In order to reduce the loan-to-income ratio by 10 per cent, a loan-to-income cap must be introduced that reduces borrowers' loan-to-income ratio, i.e. their debts in relation to their wage income, by 25 percentage points from 251 to 226 per cent. The column at the far right in Table 2 shows the long-term effects this would have. Where the borrowers are concerned, this means that consumption of both goods and leisure increases. The fact that consumption of housing services increases is also noteworthy. This shows that a tightening of the loan-to-income cap need not in itself dampen borrowers' housing consumption. The lenders, for their part, cut down on their consumption of goods, housing services and leisure due to lower interest income. In purely qualitative terms, a tightening of the loan-to-income cap, or a tightening of the amortisation requirement, affects households in a similar way, although the quantitative effects differ.

Table 2. Long-term effects of tightened macroprudential measures
Per cent, except the amortisation requirement, which is in years

	Loan-to-value cap	Amortisation requirement	Loan-to-income cap
Initial value	75.0	50.0 years	251.2
End value	69.5	44.9 years	226.1
Loan-to-income ratio, change	–10.0	–10.0	–10.0
Borrowers			
Consumption goods, change	2.0	1.5	1.2
Consumption housing services, change	–1.7	0.2	1.2
Leisure, change	1.2	0.9	1.0
Lenders			
Consumption goods, change	–0.6	–0.5	–0.5
Consumption housing services, change	1.0	–0.1	–0.5
Leisure, change	–0.1	–0.1	–0.1

5.4 Effects of reducing the tax relief on mortgage interest

People who borrow money to purchase a home can, in their tax returns, deduct from their taxed amount 30 per cent of paid interest expense. This can be viewed as a government subsidy of loan financing to purchase a home.[19] If the tax relief on mortgage interest decreases, the subsidy will be less, and hence so too the Government's expenditure for it. The effect of reducing tax relief on mortgage interest therefore depends on what the Government uses the money for instead. In practice, it could be used to increase transfers, reduce taxes, increase public expenditure or to pay back the sovereign debt. In our model, which has a relatively simplistic description of the public sector, the funds released can only be used to increase transfers to lenders and borrowers, or to increase public consumption.[20, 21]

5.4.1 Decreasing the tax relief on mortgage interest lowers the borrower's consumption of housing services

We will study three different scenarios to illustrate what the effects will be from reducing the tax relief on mortgage interest, and how those effects depend on what the Government uses the released budget funds for. In the first scenario, the Government transfers the money to borrowers and lenders in proportion to the wage sum for each category of household. In the second scenario, the Government transfers the money entirely back to the borrowers. This means that the distorting effects of the tax relief on mortgage interest are weeded out. This scenario thus gives an indication of the extent to which the loan subsidy adds to excessive indebtedness and hence loan financing of home purchasing. In the third scenario, the Government instead uses the money entirely to boost public consumption.

In all three scenarios, the tax relief on mortgage interest declines to the level required to bring the loan-to-income ratio down by 10 per cent. In the first case, when the released budget funds are transferred to all households, the tax relief on mortgage interest must be reduced from the current level of 30 per cent to around 3 per cent, as shown in Table 3. The borrowers are affected mainly through two channels. First, the distorting incentives to take on debt will be lower. Second, they are subject to a negative effect on income because less than half of the released budget funds from the tax relief on mortgage interest are transferred back to them. On the whole, this leads to borrowers' consumption of housing

19 Refers to interest expenses up to SEK 100,000 annually.
20 In the model, there are no distorting effects from taxes, with the exception of the tax relief on mortgage interest, so there is no difference between increasing transfers and reducing taxes.
21 See also Englund (2016) for a study of the effects of reducing tax relief on mortgage interest.

services declining by around 7 per cent, while at the same time their consumption of goods and leisure is more or less unchanged. Where the lenders are concerned, the reduction in the tax relief on mortgage interest gives a positive effect on income, because more than half of the money is transferred to them. Therefore, consumption of both goods and housing services increases.

In the second scenario, the money from the tax relief on mortgage interest is transferred entirely back to the borrowers. In order for the loan-to-income ratio to decline 10 per cent, the tax relief on mortgage interest must be reduced to around −6 per cent in this case. The tax relief on mortgage interest being negative means that it is a tax on loan financing for homes. So, a 6 per cent tax on loans for homes is needed for the loan-to-income ratio to decrease by 10 per cent. In that case, borrowers' consumption of housing services declines by more than 6 per cent, while consumption of goods increases by over 3 per cent, and leisure by around 2 per cent. These calculations illustrate the distorting effects of the tax relief on mortgage interest, because the Government fully transfers back the money from the tax relief on mortgage interest to the borrowers. The tax relief on mortgage interest thus leads to the borrowers consuming "too much" of housing services, but also to them consuming "too little" of other goods. The lenders, for their part, cut down on their consumption of goods and leisure due to lower interest income. However, their consumption of housing services increases because the total housing stock is unchanged.

In the third scenario, the Government uses the money from the tax relief on mortgage interest entirely to boost public consumption. In order for the loan-to-income ratio to decline 10 per cent, in this case it suffices to reduce the tax relief on mortgage interest to around 6 per cent. It is therefore the most appropriate alternative if the aim of reducing the tax relief on mortgage interest is solely to reduce household debt. Where the borrowers are concerned, however, it is an expensive alternative – despite interest expense being lower – because they miss out on the entire loan subsidy. The borrowers' consumption of housing services declines by over 6 per cent and the consumption of goods and leisure by just shy of 1 per cent each. The consequences for lenders are more beneficial. Consumption of housing services increases by just shy of 4 per cent, while at the same time the consumption of goods and leisure is more or less unchanged. However, in order to perform an accurate macroeconomic evaluation of this alternative, the utility to households provided by higher public consumption must also be weighed in.

Table 3. Long-term effects of reducing tax relief on mortgage interest
Per cent

	Transfers to both borrowers and lenders in proportion to total salary	Transfers only to borrowers	Public consumption
Initial value of tax relief on mortgage interest	30.0	30.0	30.0
End value of tax relief on mortgage interest	2.8	−6.5	6.2
Loan-to-income ratio, change	−10.0	−10.0	−10.0
Borrowers			
Consumption of goods, change	−0.1	3.1	−0.8
Consumption housing services, change	−7.0	−6.1	−6.4
Leisure, change	0.1	1.8	−0.5
Lenders			
Consumption of goods, change	0.5	−1.1	0.1
Consumption housing services, change	4.2	3.7	3.8
Leisure, change	0.4	−0.3	−0.1

5.5 Which measure is the most effective in reducing household debt?

There are different ways of evaluating which measure is the most effective in reducing household debt from a macroeconomic perspective. In the model, household utility is an appropriate measure for such an analysis. The utility depends on the consumption of goods, housing services and leisure. The fact that the utility is affected by leisure is an important assumption because it means that an increase in consumption due to working more does not necessarily increase household utility, because a higher labour supply means less leisure time.

GDP per capita is another measure that is commonly used to quantify macroeconomic benefit or welfare in a society. It is a simple measure and is therefore often used in practice. However, a drawback with GDP per capita is that welfare does not only consist of material wellbeing, but also other factors that are more difficult to measure, such as leisure and health.

Table 4 shows the effects of reducing the loan-to-income ratio by 10 per cent through the four different measures that we analysed above: loan-to-value cap,

amortisation requirement, loan-to-income cap and tax relief on mortgage interest. For the tax relief on mortgage interest, we show the same three cases as before. In the first two, the money released from the tax relief on mortgage interest is used for transfers to households, and only to borrowers in the second. In the third case, the money is used for public consumption. As a measure of household welfare from a macroeconomic perspective, household consumption of goods, housing services and leisure is shown on the one hand, and GDP per capita on the other.[22]

The households' aggregate consumption of housing services is not changed by the various measures, because the total supply is constant. If the borrowers and lenders value housing services consumption in the same way, the effects on households' housing consumption would thus have no bearing on judging which measure is most effective for reducing indebtedness.[23] The change to the consumption of goods is also close to zero for these measures, although it increases by around 0.2 per cent for the tax relief on interest income when the Government uses the money released for transfers to both categories of household. The change to households' leisure is of greater significance, declining by 0.3 per cent when the government uses the money released from reduced tax relief on mortgage interest for public consumption, but increases by 0.6 per cent when the money is instead used for transfers to borrowing households only. The change in public consumption from these measures also appears to be significant, particularly when the Government uses the money from the reduced tax relief on mortgage interest payments for public consumption. In that case, public consumption increases by 2 per cent.

These results show that, from a macroeconomic perspective, it is difficult to draw any clear-cut conclusions about which measure would be most effective in reducing household debt. The three macroprudential measures have slight effects on consumption of goods, while leisure increases by around 0.3-0.4 per cent, but public consumption drops by around as much. In terms of the tax relief on mortgage interest, the effects also diverge slightly. If the budget funds released from reducing tax relief on mortgage interest are used for transfers to all households, the improvement would however be clear because consumption of both goods and leisure increases while at the same time consumption of housing services and public consumption are unchanged.[24]

22 The population is normalised to one, and hence there is no population growth in the model, so GDP and GDP per capita are the same.

23 In the model, the borrowers gain slightly more utility than the lenders from consuming housing services, so the difference in terms of utility is not zero.

24 The fact that household consumption of goods can increase at the same time as GDP per capita decreases is due to a reduction in both capital formation and the consumption of entrepreneurs.

If the macroeconomic effects are instead evaluated using GDP per capita, a reduction in tax relief on mortgage interest, with the reduction in Government expenditure being used for public consumption, is most effective. That measure would increase GDP by around 0.3 per cent. It is worth noting that all other measures lead to a reduction in GDP per capita, because those measures lead to households opting for more leisure time, so the number of hours worked will be lower.

Table 4. Long-term effects of reducing the loan-to-income ratio by 10 per cent from a macroeconomic perspective
Per cent

	Mortgage cap	Amortisation requirement	Loan-to-income cap	Tax relief on interest expense transfers to both borrowers and lenders	Tax relief on interest expense transfers to borrowers only	Tax relief on interest expense public consumption
Initial value	75.0	50	251.2	30.0	30.0	30.0
End value	69.5	44.9	226.1	2.8	−6.5	6.2
Loan-to-income ratio, change	−10.0	−10.0	−10.0	−10.0	−10.0	−10.0
Consumption						
Goods, change	0.0	0.0	−0.1	0.2	−0.1	−0.1
Housing services, change	0.0	0.0	0.0	0.0	0.0	0.0
Leisure, change	0.4	0.3	0.4	0.3	0.6	−0.3
Public consumption, change	−0.4	−0.3	−0.4	0.0	0.0	2.0
GDP per capita, change	−0.4	−0.3	−0.4	−0.3	−0.6	0.3

6 What are the short-term implications for monetary policy of reducing household debt?

Changes to the various macroprudential measures and to the tax relief on mortgage interest have long-term macroeconomic effects, but can also have short-term effects on, for instance, demand and inflation. The tax relief on mortgage interest affects demand in the economy through changes in public sector income and expenditure, while various macroprudential measures affect demand through household dept. The central bank may need to consider this when setting the policy rate.

In order to evaluate the implications for monetary policy from reducing household dept, we have studied the effects of introducing the four different measures (loan-to-value cap, amortisation requirement, loan-to-income cap and tax relief on mortgage interest). Each measure is introduced at a certain point in time, and is then in place for a long time, but gradually reverts to its original level. In all cases, the levels of the various measures are set such that household dept after 10 years is around 10 per cent lower than its initial level.

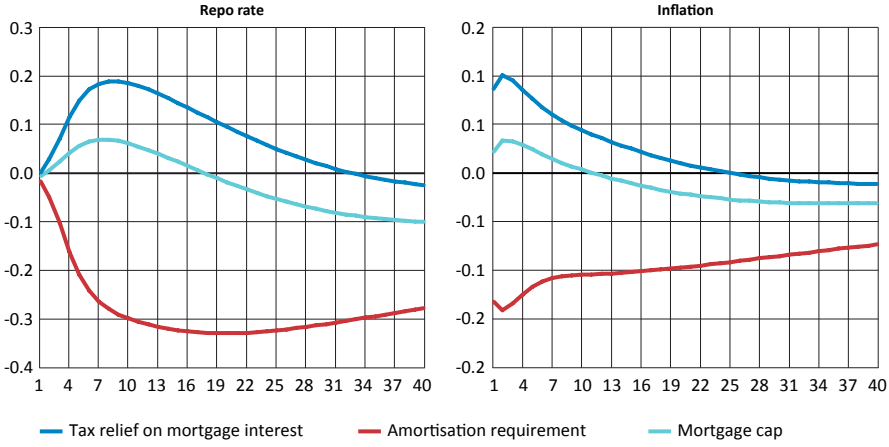
We show that an important factor affecting the measures' short-term effects is mobility on the housing market. We compare two cases. In one case, mobility on the housing market is high, but low in the other case.

Figure 6 shows how inflation and the policy rate are affected if household debt declines when mobility is high. Reducing the loan-to-value cap or tax relief on mortgage interest has similar effects on the policy rate and inflation. Inflation rises at most by just under 0.2 per cent and the policy rate by 0.2 per cent. Tightening the amortisation requirement has the opposite effect on the policy rate and inflation, however, as both decreases with this measure.

In the case when mobility instead is low, the effects on the policy rate and inflation are different, as shown in Figure 7. Inflation declines irrespective of the measure and by up to almost half a percentage point when amortisation requirements are tightened. The central bank therefore cuts the policy rate to dampen the drop in inflation.

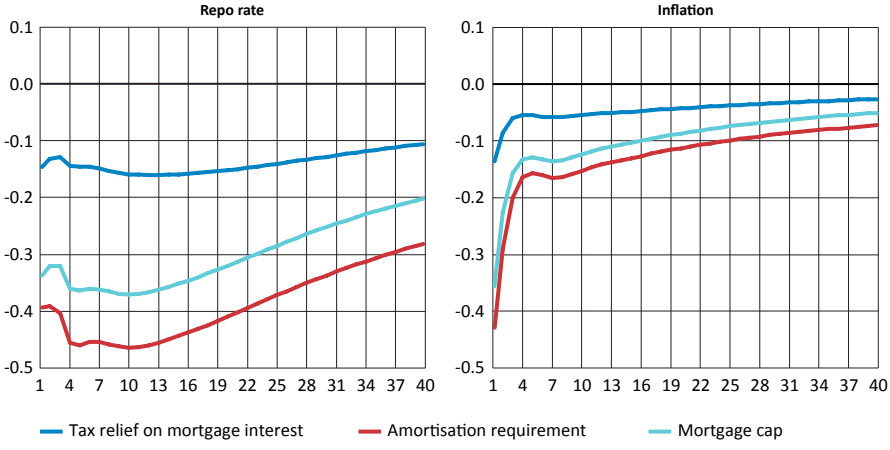
The impact on monetary policy therefore does not only depend on which measure is implemented, but also the extent of mobility on the housing market. If mobility is low, households are forced to cut down on their consumption of other goods. In that case, inflation will be lower and monetary policy more expansionary. However, this also leads to a drop in mortgage rates, which partially counteracts the effects of the measures on indebtedness. The findings thus illustrate that the different measures have implications for monetary policy that may diverge, and that it is important to also consider mobility on the housing market.

Figure 6. A tightening of the loan-to-value cap, tax relief on mortgage interest and amortisation requirement with high mobility on the housing market
Deviations from long-term levels, in percentage points



Source: Own calculations

Figure 7. A tightening of the loan-to-value cap, tax relief on mortgage interest and amortisation requirement with low mobility on the housing market
Deviations from long-term levels, in percentage points



Source: Own calculations

7 How does the level of long-term debt affect monetary policy?

The rapidly increasing indebtedness of Swedish households since the mid-1990s has probably made many households more sensitive to changes in interest rates. If interest rates rise, this has a direct effect on the households' disposable income, and brings about a redistribution of resources from borrowers to lenders. The higher the indebtedness, the greater the effect of a rate hike on borrowers' interest expense and disposable income, which in turn reduces households' scope for other consumption. However, the extent of the impact depends on several factors, such as how long a rate hike lasts, and how the debts are distributed among the households.

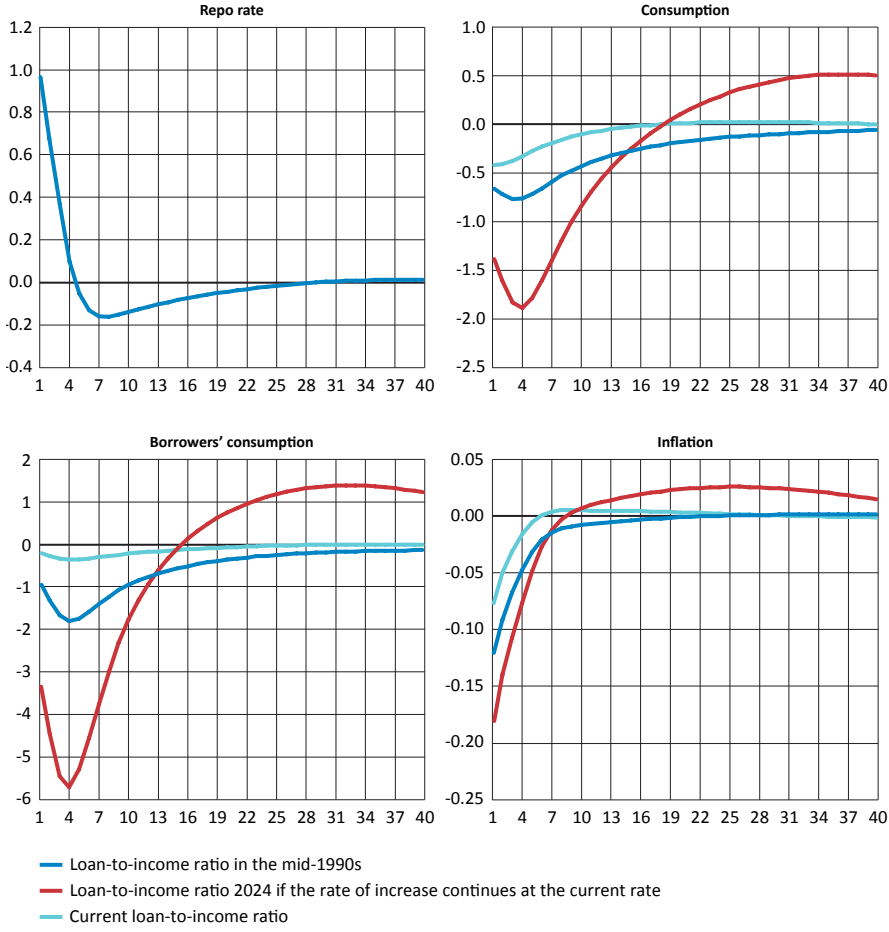
According to this argument, the impact of a policy rate hike on demand – and hence on inflation – would be greater now than before. In order to illustrate the potential extent of the effects, we compare how the effects differ depending on three different loan-to-income ratio levels, see Figure 8. In all three cases, the repo rate is increased by 1 percentage point to be then adjusted back to the original level according to the monetary policy rule (see equation (7)). In the first case we assume that the loan-to-income ratio is at the present level, i.e. close to 180 per cent, when the rate hike occurs. In that case, the aggregate consumption of households (both borrowers and lenders) declines by around 0.7-0.8 per cent in the first year. But the borrowers are the ones hardest hit by the rate hike. Their consumption drops by almost 2 per cent, while the lenders' consumption is largely unaffected. We can also see that inflation drops by just over 0.5 percentage points.

We can compare that case with what the effects on consumption and inflation would be had the loan-to-income ratio instead been at the same level as when the inflation target was introduced in the mid-1990s, i.e. around 90 per cent. In this case, the effect on consumption will, as expected, be smaller, and in particular the effect on the borrowers' consumption will be much smaller. Their consumption only drops by a couple of tenths of a percentage point. The effect on inflation is also smaller, although the difference is relatively small.

In the third case we assume a loan-to-income ratio of 210 per cent. That level could be reached within 10 years if the loan-to-income ratio continues to increase at the current rate from today's level. With that debt level, the effects of a rate hike on consumption would be much greater. For example, an interest rate that is one percentage point higher could lead to a drop in borrowers' consumption of almost 6 per cent. The impact on inflation would also be greater.

These calculations provide an indication of the importance of the household loan-to-income ratio on the transmission mechanism of monetary policy. The higher the loan-to-income ratio, the greater the share of borrowers' income that will be spent on interest payments and consumption of housing services, and the lower the amount that can be spent on consuming goods.

Figure 8. Effects of hiking the repo rate at different loan-to-income ratios
Deviations from long-term levels in per cent, in percentage points (repo rate, inflation) and per cent (consumption)



Source: Own calculations

8 Concluding remarks

We have shown that, over time, household debt could be reduced by tightening different macroprudential tools and reducing the tax relief on mortgage interest. This would also lead to a redistribution of resources from lenders to borrowers. This redistribution effect is contrary to the conventional wisdom according to which macroprudential measures are negative for borrowers. Forlati and Lambertini (2014) describe similar findings. They study the effects of the new loan contracts with lower down payments and lower amortisation requirements that came into use in the US in the latter half of the 1990s. In their model, easier access to credit pushes borrowers to borrow more and demand more housing services, without considering the impact of their behaviour on housing prices. In the aggregate the resulting higher housing demand will push-up house prices. As a result, borrowers will have to cut down their consumption and work more, thereby reducing their welfare in the long term.

We have also shown that a reduction in the tax relief on mortgage interest affects households in different ways, depending on how the Government chooses to use the money instead. If it compensates the borrowers, such a measure can be positive for their consumption other than housing. Hence, those that may be hurt financially of a reduction in the tax relief could be compensated with other transfers.

A caveat of our analysis is that we disregard the impact of household debt on the risk of entering a financial crisis. The main purpose of macroprudential policy is indeed to prevent financial crises, and that is also important from a macroeconomic perspective. This is however something we cannot quantify in the model we have used.

Another conclusion from the analysis is, not surprisingly, that the different measures have implications for monetary policy that can go in different directions and are affected by the extent of mobility on the housing market. Using the model, we have also illustrated how the level of household debt affects the impact of monetary policy on the rest of the economy.

A limitation in this study is that we have disregarded foreign trade and possibilities of cross-border transactions. The results in Chen and Columba (2016), however, show that this does not affect the results to any considerable extent in a model similar to ours. They also analyse the effects of various macroprudential measures on household debt, and their findings are in line with ours.

The National Institute of Economic Research (2016) has recently conducted a study to assess the macroeconomic impact of introducing a loan-to-income cap. Assuming that all borrowers borrow up to the limit, they conclude that the

introduction of the new policy will lead to a decrease in the household loan-to-income ratio by 11-14 percentage points after 10 years while nominal GDP will be 0.1-1.7 per cent lower, and the price level measured by the CPIF 0.1-0.7 per cent lower. According to our model, real GDP declines by 0.4 per cent in the long term.

Another study that looks at how household debt is affected by macroprudential and fiscal policies, i.e. a property tax and tax relief on mortgage interest – is Alpanda and Zubairy (2016). Their model is calibrated on US data and has a relatively detailed description of the mortgage market, but lacks a banking sector which intermediates funds between lenders and borrowers. According to their analysis, the most efficient policy is reducing the mortgage interest duduction, followed by tightening the loan-to-value cap and introducing a property tax.

In our macro model, we make the simplified assumption that borrowers are always limited by a loan restriction. Both Hull (2015) and Svensson (2016) diverge from that assumption and study effects of amortisation requirements using – in some regards – more detailed models of the loan contracts. Hull (2015) studies the amortisation requirement introduced by Finansinspektionen on 1 June 2016. In his model, besides amortisation requirements, households must also meet a debt service ratio cap. The analysis is conducted in an "overlapping generation model" with 60 generations, in which the loan contracts of the household sector are largely consistent with the actual design of loan contracts in Sweden with Swedish-style mortgage contracts. According to Hull's analysis, amortisation requirements lead to somewhat smaller effects than in our model (the household loan-to-income ratio decreases by just over 2 percentage points at most), because the households can optimally choose to regularly renegotiate their loans.

According to Svensson (2016) household debt could, on the contrary, increase rather than decrease if an amortisation requirement is introduced. This is because households can choose the same savings as without amortisation requirements by borrowing more initially, investing the surplus in a savings account and then making withdrawals at the rate required to meet the amortisation requirement. The average debt will therefore be higher than without amortisation requirements. A crucial assumption in Svensson's analysis is that mortgages are not limited at the same time by loan-to-value caps, loan-to-income caps or other factors that prevent borrowers from financing their amortisations with loans, such as the cost of renegotiating loans.

Just like in the theoretical literature, the empirical literature contains a high degree of uncertainty about which effects various macroprudential tools have. Guibourg et al. (2015) summarise the findings of some important empirical studies. Several of these studies show that both loan-to-value caps and loan-

to-income caps can be effective in preventing household mortgages from rising too quickly. Loan-to-value caps and loan-to-income caps also appear to be the macroprudential tools most used to reduce demand for credit, and often in combination with each other. Housing-related taxes such as property tax or tax relief on mortgage interest also have effects on mortgages. Housing-related taxes and loan-to-value caps also appear to have significant effects on house prices.

In this study, we have quantified by how much different macroprudential policies and mortgage interest deductions have to be tightened in order to attain a certain effect on the loan-to-income ratio. The macroeconomic effects of these different measures will be fairly equal for the population on average, but differ between borrowers and lenders.

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Revisiting the role of central banks as liquidity providers – old and new challenges

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This article offers a review of the role of central banks as providers of public liquidity. Against the backdrop of the global financial crisis of 2007-2009, we discuss various challenges for public liquidity provision and the effectiveness of central bank lending facilities. These challenges help us identify potential gaps in existing mechanisms and frameworks governing liquidity assistance. We discuss how the available liquidity policy tool kit can be used to deal with the challenges. Furthermore, we highlight modifications to existing central bank facilities during and after the global financial crisis. We point at trade-offs faced by policy makers and describe potential pitfalls for public liquidity providers. Lastly, we attempt to look ahead and outline some specific challenges posed by more recent structural, regulatory, and technological developments in the financial system.

1 Introduction

Central bank liquidity provision is related to all core tasks within the central bank mandate. It constitutes an important pillar for the transmission of monetary policy and the smooth functioning of the payments system, as well as for safeguarding financial stability. In relation to the latter task, central bank liquidity provision has played a key role in responding to liquidity crises since Bagehot (1873). This role became evident during the Global Financial Crisis in 2007-2009 (henceforth GFC),

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where the backstop provided by central banks acting as *lenders-of-last-resort* (LLRs) was instrumental in avoiding a melt-down of the financial system.

The objective of this article is to offer a review that could help enhance our understanding of liquidity provision and the role of central banks as providers of *public liquidity*. In this, challenges for the effectiveness of central bank lending facilities are given special attention. In light of the recent crisis experience, potential gaps in existing mechanisms and frameworks governing central bank liquidity provision are identified and discussed. Furthermore, we attempt to provide an analysis of the potential pitfalls, such as unintended implications for the behavior of financial institutions that may arise from the availability of certain lending facilities. The purpose of this article is not to generate specific policy recommendations, but rather to provide a descriptive and conceptual basis for further policy discussions.

We start off by describing what a private liquidity system would look like in an ideal world. Thereafter, we discuss relevant market failures that are associated with financial frictions. The resulting inefficiencies justify the provision of liquidity by central banks, which can improve the allocation of resources. We then describe the policy tool kit employed by central banks to achieve their objectives and consider the associated challenges. Furthermore, we examine how challenges can be dealt with. Our discussion is framed with the help of idiosyncratic and system-wide liquidity stress events that are motivated by the recent GFC.

During the last two decades, the financial system has undergone structural and regulatory changes that affect liquidity in financial markets and the conduct of public liquidity provision in both crisis times and normal times. At the same time, doctrines for central bank liquidity assistance (LA) have been questioned, not least during the recent GFC, when governments and central banks all over the world were forced to make massive interventions in the form of state guarantees and liquidity support to address system-wide liquidity stress. At the time, central banks reacted with ad-hoc modifications to their tools and practices, so as to address the emergence of new challenges to the effective provision of liquidity to financial institutions and markets. After the crisis, several central banks also made more permanent modifications to their LA frameworks. This included broadening the terms for existing facilities, creating new permanent and contingent facilities, and re-considering the degree of transparency of central bank communication.

Besides challenges related to systemic stress events such as the ones experienced in the GFC, this article also covers challenges related to idiosyncratic stress events and implications for liquidity provision in normal times. More generally, our focus is on specific aspects that are important when it comes to effective provision of liquidity to market participants in need, such as shortage

of eligible private collateral, solvency assessment, adjustment of LA to changing needs, and potential problems related to stigmatization of central bank lending facilities.

When evaluating the central bank policy tool kit, as well as potential gaps in lending facilities, it is essential to reflect on the effects of public liquidity provision on the behavior of financial intermediaries and markets. To this end, we offer a detailed account of the academic literature on public and private liquidity provision. We highlight challenges to central bank liquidity provision stemming from behavioral effects, such as implications for risk-taking and market discipline, impairment of private liquidity provision, and distortions in the allocation of credit. Moreover, we set liquidity provision in the context of monetary policy. Looking ahead, we identify future challenges related to the nexus between emergency LA and bank resolution, the high intensity of cross-border banking activities which is particularly relevant for Sweden and recent developments in financial markets.

The article is organized as follows. Section 2 presents the conceptual underpinnings of private and public liquidity provision, introducing the important role played by central bank liquidity provision, which is set in context with monetary policy. Section 3 discusses the tools and goals of a public liquidity provider. Thereafter, Section 4 describes the challenges and Section 5 how they can be dealt with. Section 6 discusses potential pitfalls and trade-offs from the viewpoint of central banks. Then Section 7 tries to look ahead at new challenges going forward and some concerns from the Swedish perspective. Finally, Section 8 concludes.

2 Central bank liquidity provision

Before discussing the conceptual underpinnings of private and public liquidity provision, we define some key terms (Table A.1 in the Appendix summarizes definitions). The term liquidity is related to the ease of transferring future income from long-dated assets into current income. Since liquidity is provided by both the private and the public sector, we can distinguish between *private liquidity provision* by financial institutions and *public liquidity provision* by the government or central bank. Furthermore, the literature distinguishes between *funding liquidity* and *market liquidity*. Funding liquidity refers to the ease with and cost at which financial institutions raise cash to make their immediate payments, either via collateralized debt or by selling assets. Market liquidity refers to the ability to execute large security transactions rapidly with a limited impact on market prices. Liquid financial markets are important for the allocation of resources in the

economy and to fund real investments. Thereby, liquid financial markets facilitate economic activity and growth. The two concepts of funding liquidity and market liquidity are closely related. While market liquidity is positively associated with funding liquidity, it is also the case that funding liquidity facilitates market liquidity through its positive effect on market-making.

In the domain of public liquidity provision, central banks play a prominent role by regulating *central bank liquidity*. We use this term to describe central bank money or securities that serve as collateral in money markets. Central bank money consists of financial institutions' deposits at the central bank (also known as reserves or settlement balances).[1] Especially in crisis times, central bank liquidity provision can be positively associated with funding and market liquidity. We'll come back to central bank money when discussing the liquidity policy tool kit in Section 3.

We proceed by discussing in Section 2.1 what a private liquidity system would look like in an ideal world. Furthermore, we describe how market failures can justify the provision of public liquidity. Then we highlight in Section 2.2 the role of central banks as the natural providers of public liquidity from a conceptual viewpoint. Thereafter, Section 2.3 illustrates the historical relevance of central banks in safeguarding financial stability and Section 2.4 discusses the goals of central banks as liquidity providers. Finally, Section 2.5 discusses the close connection between monetary policy and liquidity policy.

2.1 Private liquidity provision – and its limitations

the classical business of financial intermediaries is to engage in *maturity transformation* by attracting short- and medium-term deposits that are used to fund long-term loans to corporates and households. This is an important role of financial intermediaries, because some financial investors prefer deposits that are short-term or demandable when they believe that potential liquidity needs (Bryant 1980; Diamond and Dybvig 1983) or investment opportunities (Holmström and Tirole 1996) may arise in the future. Instead, borrowers who want to fund investments prefer to match the maturity of their loans with the maturity of their investments, which are often longer-term. For corporate borrowers, such long-term investments may be in production plants or buildings, whereas for households investments may be in residential property or durable goods. By matching short-term funding with longer-term investments,

1 These reserve balances are held by financial institutions to achieve final settlement of all financial transactions in the payments system (and, to the extent such requirements are applied, to meet central bank reserve requirements). Individual institutions can borrow and lend these funds in the interbank market, but the central bank is the only source of these funds for the system as a whole.

financial intermediaries build up a *maturity mismatch* on their balance sheet. While engaging in maturity transformation, intermediaries also engage in *risk transformation* by funding risky investments with riskless deposits (e.g., Diamond (1984)). Furthermore, intermediaries provide liquidity risk sharing opportunities to their customers in the form of demandable deposits, credit lines or market-making services. *Maturity transformation* and *liquidity insurance* expose intermediaries to a number of risks, including *liquidity risk*, which captures the financial risk stemming from the difficulty of selling a claim against a long-term investment quickly in order to make immediate payments to customers.

In the benchmark of an "ideal world" private liquidity system, financial intermediaries contribute to allocative efficiency by engaging in maturity transformation. Furthermore, financial intermediaries provide welfare-enhancing liquidity risk sharing opportunities to customers and efficiently share their own liquidity risk with other intermediaries via interbank markets by providing private liquidity to one another (Allen and Gale 2004). To manage their liquidity risk, intermediaries can limit the maturity mismatch by holding a sufficiently high proportion of reserves with the central bank and highly liquid securities such as government bonds. These liquidity holdings have a *precautionary* and a *speculative* component. On the one hand, liquid assets serve as a buffer against unexpectedly high outflows of funds. On the other hand, financial intermediaries can benefit from providing liquid assets to the market whenever their individual outflows of funds are small. In an "ideal world", the precautionary and speculative motives are balanced to ensure an efficient level of private liquidity provision.

The real world, as opposed to this "ideal world" is however prone to various market failures causing inefficiencies that can justify the provision of liquidity by the central bank, as well as regulatory policies such as liquidity regulation, bank capital regulation, and prompt corrective action.[2] One source of market failure is the *incompleteness of financial markets and contracts* (Allen and Gale 2004). Notably, the occurrence of liquidity crises that are associated with failures of financial intermediaries in itself must not be inefficient (Allen and Gale 1998). However, incomplete markets and contracts can impair the incentives for private liquidity provision and lead to *asset fire sales* and an inefficiently high incidence of liquidity crises. Insufficient incentives for private investments in liquid assets have also been associated with distortions related to *asymmetric information* (Greenwald and Stiglitz 1986; Geanakoplos and Polemarchakis 1986), *moral hazard* (Bhattacharya and Gale 1987) and *monopoly power* (Acharya, Gromb and Yorulmazer 2012).

2 See De Nicolò (2016) or Allen (2014) for a review.

In private liquidity systems with asymmetric information and incomplete contracts, financial intermediaries can be prone to *panic-based runs* (Diamond and Dybvig 1983) or *information-based runs* (Chari and Jagannathan 1988, Jacklin and Bhattacharya 1988, Rochet and Vives 2004). Furthermore, the presence of *contractual incompleteness* or *asymmetric information* can reduce the abilities of intermediaries to pledge future cash flows (Hart and Moore 1988). The same is true for *moral hazard* stemming from *unobserved costly effort* by financial intermediaries (Holmström and Tirole 1997), which can be related to an insufficient effort in risk management or in the monitoring of loans. Moreover, *agency problems* can also be associated with a different type of *moral hazard* resulting from *risk-shifting* on the asset side (Jensen and Meckling 1976), potentially in combination with deposit insurance (Cooper and Ross 2002, Calomiris and Jaremski 2016a,b), or bailouts.[3] Finally, an inefficiently high incidence or intensity of liquidity crises in private liquidity systems can also be associated with *network externalities* or *contagion risk* resulting from the interconnectedness of financial intermediaries.[4]

Due to the above mentioned market failures, the aggregate level of private liquidity creation may at times be either excessive or insufficient. Diamond and Rajan (2000,2001) show that higher leverage and, hence, greater financial fragility can be positively associated with liquidity creation. On the other hand, adverse shocks can lead to a reduction in liquidity creation, and even more so if the fragility of financial intermediaries is higher. Acharya and Naqvi (2011) link the access of abundant liquidity to the formation of *asset price bubbles* and greater risk-taking due to an agency problem, thereby sowing the seeds of the next crisis. In empirical work, Berger and Bouwman (2009,2011) study the evolution of liquidity creation by U.S. banks and find that high bank liquidity creation has some explanatory power in predicting the GFC of 2007-2009 (with an important role played by off-balance sheet liquidity creation). Whether there is an "optimal scale" of liquidity creation in the banking system is still an open question (Berger and Bouwman 2016).

The various market failures can justify government intervention and regulation. Specifically, one can distinguish between policies that mitigate the adverse effects of a crisis and policies that aim at preventing crises (De Nicolò 2016). The former polices are related to *ex-post* government inventions such

3 Besides the adverse effects of expected bailouts on risk management and risk-shifting (Perotti and Suarez 2002), there may also be adverse effects associated with the collective competitive behavior of banks (Bertsch et al. 2014).

4 Possible contagion channels include financial and balance sheet links (Rochet and Tirole 1996, Allen and Gale 2000), information contagion (Acharya and Yorulmazer 2008), a common investor base (Goldstein and Pauzner 2004), and wake-up calls (Ahnert and Bertsch 2015).

as guarantees or bailouts and to central bank LLR measures (liquidity support to financial institutions or markets). Instead, the latter policies have an *ex-ante* nature and are mostly related to financial regulation, prompt corrective action and deposit insurance. However, the availability of central bank lending facilities and the ex-ante transparency thereof can also play a role when it comes to preventing crises, as well as effects on the incentives for private liquidity provision (Acharya et al. 2011).

In this paper, we focus on the provision of liquidity by central banks and how these interventions can improve the allocation of resources. Therefore, we treat in most of our analysis financial regulation as given, but acknowledge the important role played by these policies when attempting to prevent crises. In fact, recent regulatory initiatives such as the *Liquidity Coverage Ratios (LCRs)* and *Net Stable Funding Ratios (NSFRs)* address market failures associated with insufficient incentives for financial institutions to invest in liquid assets.[5 6] Similarly bank capital regulation is usually associated with efforts to deal with moral hazard and insufficient incentives for financial institutions to maintain loss buffers.

We next turn to the role of central banks as providers of public liquidity and discuss the relationship with private liquidity provision from a conceptual viewpoint.

2.2 Central banks as the natural providers of public liquidity

Central banks are the "natural" providers of *public liquidity* and play an important role in regulating liquidity in the financial system by lending (against collateral) to, or borrowing from, financial institutions. The ability of central banks to perform this role in a fiat currency system derives from their power to regulate central bank liquidity by providing virtually unlimited quantities of liquidity in their own money. Financial institutions rely on functioning interbank markets to withstand temporary liquidity shortages. In normal times, banks provide unsecured or secured lending to one another at terms that are closely related to the central bank's refinancing rate. With the help of overnight refinancing facilities, central banks can smooth out the aggregate liquidity need of the banking system and thereby mitigate excessive volatility of asset prices (Allen et al. 2009). Central banks do this via a circle of counter-parties for their operations, which comprises a

5 Perotti and Suarez (2011) outline a Pigovian approach to liquidity regulation in a model with systemic externalities and contrast it with quantity regulation (e.g. NSFRs).

6 For the LCR see the Basel Committee on Banking Supervision (2013) and for the NSFR see the Basel Committee on Banking Supervision (2014), as well as earlier documents (Basel Committee on Banking Supervision 2010a; 2010b).

number of commercial banks that hold reserves and can act as intermediaries for the broader financial system.

By supporting the functioning of an interbank market for liquidity risk sharing and providing an insurance against aggregate fluctuations, central banks can facilitate financial intermediaries' engagement in maturity transformation, that is, to match short-term funding from the private sector with long-term investments. In fact, central banks may have a "comparative advantage in providing contingent liquidity" (Holmström and Tirole 2013, p. 125) relative to the private sector in instances of an adverse economic shock that leads to a scarcity of private sector collateral. During a financial crisis, central banks can expand their lending and widen the pool of eligible collateral and counterparties to mitigate disruptions of the financial system and adverse effects on the real economy, thereby assuming their role as a LLR.

In the light of the discussion of a private liquidity system and its proneness to various market failures, central banks can provide an effective backstop for banking panics (Rochet and Vives 2004) and reduce contagion risk. Besides the proneness of private liquidity systems to panic runs, adverse selection problems can also lead to hoarding behavior and liquidity dry-ups (Malherbe 2014). In this context, central banks can help to restore market functioning by overcoming adverse selection (Tirole 2012). Furthermore, central bank liquidity support can be justified if it helps to curtail the adverse effects of fire-sale externalities (Stein 2012), or the failure of too-interconnected-to-fail institutions of systemic importance (Tirole 2011).

While LLR policies deal more broadly with assistance to financial institutions or the financial market as a whole in adverse states of the economy, central banks can also provide LA selectively to individual institutions faced with severe liquidity problems and unable to borrow from other financial institutions through interbank markets. Such interventions targeted at individual institutions fall under the preface of *emergency liquidity assistance* (ELA), which is part of the domain of LLR policies. The central bank's role as provider of ELA is important since the failure of an individual financial intermediary can lead to a contraction in the liquidity pool of the financial system, giving rise to a detrimental interaction between solvency and liquidity problems (Diamond and Rajan 2005). In such a situation, the provision of contingent public liquidity may be essential in arresting financial panics. Typically, central bank mandates, or the interpretation thereof, limit ELA to illiquid but solvent financial institutions since the extension of central bank liquidity support to insolvent institutions bears social costs. The *solvency assessment*, i.e. the distinction between illiquidity and solvency, is a core challenge of LLR policy. It plays a crucial role in the design of LLR policies with

implications for the ex-ante behavior of financial institutions. Furthermore, the solvency assessment is substantially affected by institutional factors related to bank capital regulation and liquidity regulation.

From the viewpoint of market participants, the financial regulator and the central bank, the availability of *public liquidity* supplied by the central bank – in normal and in crisis times – is typically not a perfect substitute for *private liquidity* supplied by the financial system. Such an imperfect substitutability may arise for several reasons and create a social cost for public liquidity provision.

First, the supply of private liquidity plays an important role, for instance, in mitigating potential moral hazard concerns. This is because the provision of liquidity by financial institutions to one another may have a positive disciplining effect and reduce risk-shifting. Specifically, the reliance of individual financial institutions on short-term debt and the provision of private liquidity by its peers or by markets can be part of an incentive-compatible intermediation where private investors monitor the bank to prevent fraudulent behavior (Calomiris and Kahn 1991). More generally, peer monitoring can reduce moral hazard problems by exposing banks to elevated funding costs whenever misconduct is detected. Relative to public liquidity provision, the reliance on private liquidity provision can improve the monitoring if market participants have more information than the central bank or regulator. Furthermore, the exertion of *market discipline* – or punishment – after detection by market participants is a credible threat, thereby reducing the likelihood of misconduct.

Second, private liquidity provision plays an important role in assuring adequate pricing of risks in markets, which is reflected in the distribution of funding costs along different types of collateral used in repo markets. In this way, financial intermediaries face higher funding costs when shifting into riskier asset classes. The described mechanism may, however, be impaired if public liquidity provision crowds-out private liquidity provision to riskier asset classes.[7]

Third, the scope of public liquidity provision may be limited for practical and institutional reasons, which leaves an important role to be played by private liquidity provision. An example is the limited scope of central bank liquidity provision when it comes to the circle of eligible counterparties. Consequently, potential crowding-out effects on the private liquidity supply resulting from the existence of public liquidity provision may be undesirable if this puts non-eligible counterparties who do not have access to central bank liquidity provision at a substantial disadvantage. Taken together, private liquidity provision has a social value due to an imperfect substitutability of public and private liquidity provision.

7 Thereby, an abundant *public* liquidity supply may fuel risk-taking by banks, causing excessive lending and asset price bubbles. See also Section 2.1 and discussion in Acharya and Naqvi (2011).

The academic debate on the merits and different facets of private liquidity provision is still ongoing. We will come back to this as we go along. However, the importance of central bank liquidity provision to safeguard the financial system is unquestioned. We continue with a brief discussion of the historical role of central banks and the short-term funding of financial intermediaries.

2.3 Historical role of central bank liquidity provision and banks' reliance on short-term funding

The 19th and 20th centuries have been rich in banking crises. For the U.S., Schwartz (1988) identified 14 years with banking panics between 1790 and 1930. Using a different methodology, Reinhardt and Rogoff (2008) identified 11 years with banking crises in the U.S. between 1800 and 2000. Also other high-, medium- and low-income countries across the world have been affected by frequent banking crises and panics.

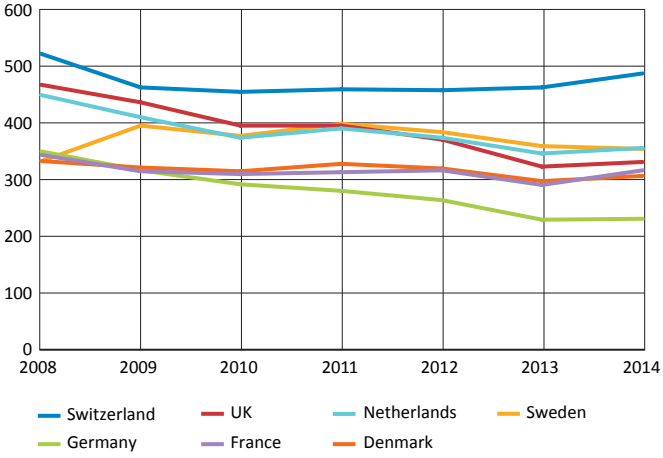
Public liquidity provision has been regarded as a key instrument to avoid banking panics and to assist banks with liquidity problems (Thornton 1802; Bagehot 1873). Historically, the presence of an active LLR has been associated with a lower incidence of banking panics when considering cross-country comparisons. Bordo (1989) argues that the Bank of England's assumption of its role as LLR reduced the incidence of banking panics in the U.K. in the second half of the 19th century relative to the U.S.

This role of central banks is as important today as it has been historically, given the increasing reliance of financial intermediaries on short-term funding. Since the late 1990s, U.S. bank holding companies have progressively shifted away from retail deposits and started to borrow *short-term wholesale funds* (Feldman and Schmidt 2001, Bradley and Shibut 2006). The U.S. non-core bank funding, mostly short-term wholesale funds, accounts for 20 percent of total bank funds (Beatty and Liao 2014). This phenomenon is strongest for larger banks and also holds for European banks. Empirical studies document that a higher reliance on short-term wholesale funds is associated with higher bank fragility (Demirgüç-Kunt and Huizinga 2010; Goldsmith-Pinkham and Yorulmazer 2010; Vazquez and Federico 2015). Markedly, this played an important role during the GFC of 2007-2009 (IMF Global Financial Stability Report, October 2013, Chapter 3). A recent study by Bao et al. (2015) gives a detailed assessment of uninsured short-term funds, or so-called *runnable liabilities*,[8] of U.S. banks during the build-up to the GFC.

8 Runnable liabilities constitute short-term liabilities without insurance or backing from the federal government that are considered to be prone to withdrawal or roll-over risk.

In Sweden, the financial system is essentially bank-based. The financial sector is large relative to the size of the economy and characterized by a strong whole-sale funding reliance. Figure 1 depicts the evolution of the size of the Swedish financial sector, measured as total assets of monetary and financial institutions (MFIs) relative to gross domestic product (GDP), and puts it in an international comparison. Figure 2 shows the evolution of highly liquid assets and runnable liabilities of Swedish MFIs.[9]

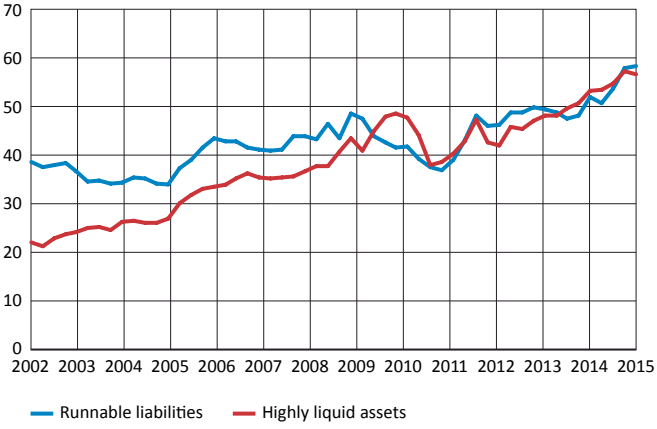
Figure 1. Cross-country comparison of total assets of MFIs
Percent of GDP



Sources: ECB, Eurostat

9 The vast majority of runnable liabilities consist of short-term money market funding, but it also includes deposits from the rest of the world (which tend to be large uninsured deposits). Given that uninsured deposits from domestic investors are not included in the runnable liabilities, it can be considered as a lower bound for the actual reliance of Swedish MFIs on short-term funding. The IMF Country Report from September 2011 indicates that the whole-sale funding reliance of the biggest Swedish banks exceeded that of its European peers during the build-up to the financial crisis. Furthermore, a significant proportion of the total funding was short-term (15 percent of the bonds had a maturity below 1 year and 20-25 percent a maturity below two years), which affected Swedish banks after the failure of Lehman Brothers in September 2008 when the U.S. dollar money market was severely disrupted causing difficulties in rolling-over debt.

Figure 2. Runnable liabilities and highly liquid assets of Swedish MFIs relative to GDP
Percent of GDP

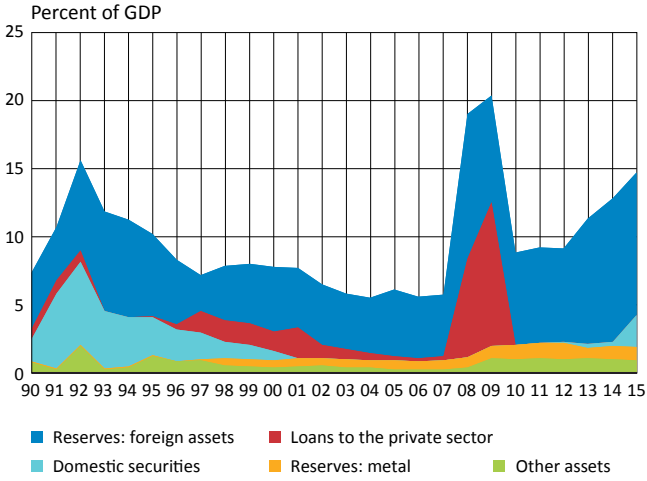


Sources: Statistics Sweden. Runnable liabilities: deposits from the rest of the world; money market papers. Highly liquid assets: cash and credit balances at central banks; treasury bills etc. eligible for central bank financing; bonds and other interest-bearing securities

In Sweden, runnable liabilities as a share of GDP are increasing. At the same time, also highly liquid assets as a share of GDP are increasing. For recent years, this may partially reflect a tightening of the liquidity regulation and an increased attention of markets to liquidity buffers of individual institutions after the GFC.

Despite improved liquidity buffers, the evolution of runnable liabilities is a relevant concern for central banks given the inherent vulnerability of runnable liabilities to systemic runs. During the GFC, central banks all over the world had to assume their role as LLR by extending about the equivalent of four trillion U.S. dollars (USD) in extraordinary LA. The necessity of this magnitude of interventions results from the vast amount of runnable liabilities on banks' balance sheets. In Sweden, the Riksbank extended a large amount of loans to the Swedish financial sector by lending against a wide range of collateral, including ELA for individual institutions. Figure 3 illustrates how the Riksbank's balance sheet grew drastically in 2008/09 from around 5 percent to over 20 percent of Swedish GDP.

Figure 3. Riksbank's assets 1990-2015
Percent of GDP



Source: The Riksbank

Taken together, the previous figures underpin the importance of central bank liquidity provision to provide a backstop against panics in the financial sector. Against the backdrop of the historical role, we discuss in the next section in more detail the goals of modern central banks as public liquidity providers.

2.4 Goals of a public liquidity provider

As indicated at the outset, central bank liquidity provision has several goals or purposes pertaining to the implementation of monetary policy, facilitating smooth functioning of the payments system, and acting as a *lender-of-last-resort* – primarily to the banking sector – in order to safe-guard financial stability.

> "*The provision of short-term liquidity is … a longstanding function of central banks, and – as we know from Bagehot and earlier authors – a principal tool for arresting financial panics*" (Bernanke 2009, p.2).

The formulation of the classical LLR doctrine is frequently attributed to Bagehot (1873), whose recommendation was to lend *early* and *largely* to *illiquid but solvent* banks, and to "lend freely at a high rate, on good collateral". From the beginning, one of the main challenges for a LLR was to distinguish between *insolvent* banks and *illiquid but solvent* banks. This distinction is especially difficult

in a crisis situation and played an important role in the academic and policy debate for years to come.

If the distinction between illiquidity and insolvency is sharp, then well-developed and well-functioning financial markets will safeguard solvent banks from becoming illiquid (Goodfriend and King 1988). In that case, it suffices to lend to the market as opposed to individual institutions. LLR liquidity assistance to individual institutions is not needed. If, on the other hand, information about solvency is imperfect, a differentiated view of the optimal LLR policy arises. Rochet and Vives (2004) have argued that lending to individual banks that are potentially insolvent may be justified to avoid inefficient liquidations if the margin of error is not too high. Similarly, systemic risk considerations may motivate assistance even to institutions whose solvency is severely questioned (Goodhart and Huang 2005; Freixas et al. 2000b).[10]

The high lending rate advocated by Bagehot, also known as *penalty rate*, has been challenged in the academic debate (Freixas el al. 2000a).[11] Moreover, penalty rates were shown to be potentially related to a higher stigmatization of central bank lending facilities (Bank of England, Winters Report 2012).[12] Still, the potential *moral hazard* associated with lending at low or zero penalties (Solow 1982; Goodfriend and Lacker 1999) remains a relevant concern.[13]

Tailored towards financial stability and crisis response, the classical LLR doctrine is still a benchmark for today's liquidity policy. Most importantly, the objective is to arrest panics by preventing idiosyncratic stress from developing into systemic stress. Furthermore, a rationale for LLR intervention is that either a payment default by an individual financial institutions or a broader shortage of market or funding liquidity can threaten the financial system's ability to fulfil a number of important functions in society. These include *the provision of payment services*, *the allocation of capital*, and *risk management*. On top of this, the functioning of the financial system is essential for the effectiveness of monetary policy. Therefore, an overarching goal of central banks acting as LLR has been to

10 In practice, central bank mandates typically exclude liquidity assistance to insolvent institutions.

11 While it served a clear role in a world with commodity money where liquidity is scarce (Martin 2009), the benefits of a penal rate are less clear in a world with fiat money.

12 The penal rate for lending at the Bank of England's discount window facility was drastically reduced following the recommendations of the Winters report (see also Box 4 in Section 5). Before 2008, the Bank of England's rate stood at 100 basis points, while the new terms foresee a volume dependent discount window rate for borrowing against level A collateral (e.g. highly liquid, high-quality sovereign debt) starting at 25 basis points. Furthermore, the average cost of borrowing against level C collateral (e.g. less liquid securitization and loan portfolios) at the discount window facility was reduced from 200 basis points to 75 basis points (Bank of England, October 2013).

13 After scrutinizing the moral hazard problem, the usefulness of penalty rates remains questionable (Freixas and Parigi 2008). The specific nature of the moral hazard problem plays an important role (Freixas et al. 2004) and a penalty rate may be ineffective or even strengthen the moral hazard problem (Repullo 2005; Castiglionesi and Wagner 2012).

avert such costly disruptions by providing an *effective backstop* for the banking and the wider financial system. This requires regular and extraordinary lending facilities to be designed in such a way that the LLR is able to reach the market participants in need of liquidity and to achieve an appropriate distribution of liquidity in the private sector. At the same time, such lending facilities should be designed in a way that limits any *distortion of credit allocation*, preserves the functioning of monetary policy transmission, and avoids an *impairment of private liquidity provision* and *market discipline*. Finally, an important goal is to protect the central bank balance sheet from unwarranted credit risk.

Relative to the classical LLR doctrine, perhaps the most significant change of paradigm over the last decade manifested itself in the change of focus from the provision of funding liquidity to individual banking institutions to markets (Mehrling 2012; Tucker 2015).[14] For example, the interventions during the GFC featured central banks as de facto *market-makers-of-last-resort* (MMLR), who lent against or purchased a wide range of core assets.[15] Contrasting with a rather traditional view on LLR policies, MMLRs acted as dealers-of-last-resort by conducting liquidity operations that target markets and certain security classes (Brunnermeier and Pedersen 2009). In addition, it shows to be of growing importance for central banks to closely monitor and understand the liquidity situation in different parts of the financial system.

2.5 Monetary policy and public liquidity provision

The domains of monetary policy and liquidity provision are closely interrelated. For example, central banks rely on a limited set of counterparties for their core monetary policy operations. Hence, the liquidity and solvency of these counterparties is crucial in achieving a distribution of liquidity to the financial system and to the real economy, as well as in assuring a well-functioning *monetary policy transmission mechanism*, which is the process through which monetary policy decisions are transmitted to the economy. This is because the monetary policy transmission relies on a positive link between the monetary policy rate and market interest rates for borrowing against securities classes that are less safe and less liquid. For this reason, the implications of liquidity policy for the supply of safe assets also play an important role as a result of the effect on credit spreads and monetary policy transmission.

14 In this context, the modern pendant to the classical penalty rate is a wide bid-ask spread around the price that would prevail in normal times.

15 In situations of severe market stress, when the market fails to match buyers and sellers at prices acceptable to both, central banks can step in as MMLR. The MMLR function can be fulfilled in two ways. First, outright purchases and sales of a wide range of private sector securities. Second, acceptance of a wide range of private sector securities as collateral in repos, and in collateralized loans and advances at the discount window.

The *easing of monetary policy* (e.g. lowering of the nominal interest rate) is commonly used to complement public liquidity provision in support of funding and market liquidity when curtailing a systemic banking crisis. Holmström and Tirole (1998) find that a loose monetary policy in adverse aggregate states of the economy may be part of a welfare-improving mechanism that redistributes resources from investors to the firms or banks in need of liquidity, thereby underpinning an effective crisis response. However, conflicts can arise, e.g. with the mandate for price stability and the stabilization of the exchange rate.[16]

There are also monetary policy implications for liquidity provision since monetary policy can affect private liquidity creation in normal and in crisis times. Berger and Bouwman (2011,2015) study U.S. banks and find that monetary policy has an effect on liquidity creation by small banks only in normal times but little effect on liquidity creation by larger banks. From a conceptual viewpoint, it is argued that expansionary monetary policy may be associated with the creation of asset price bubbles and risk-shifting (e.g., Acharya and Naqvi (2011)). In such a scenario, a central bank's liquidity policy may be able to limit such shifting into riskier asset classes by appropriately calibrating its collateral framework.

Evidently, there is a fine line between monetary policy and liquidity provision for financial stability purposes.[17] As we go along, we will highlight specific interrelations and tensions within monetary policy and liquidity provision. From the viewpoint of the liquidity tool kit discussed in Section 3, it becomes clear that certain instruments can be clearly associated with LA. Instead, other instruments are primarily designed for monetary policy purposes, but can – at times – also be employed for LA.

3 The liquidity policy tool kit

The central bank tool kit for affecting the availability of liquidity in the financial system typically consists of a number of tools that can be used to ensure the smooth functioning of the payments system, implement monetary policy, or address various forms of liquidity stress. Table 1 represents one way (out of several) in which these tools could be categorized.

16 For developing countries and emerging markets, banking crises are often associated with a full-blown balance-of-payment crisis (Reinhart and Rogoff 2009). In such a situation, an easing of domestic monetary conditions is often difficult or impossible. On the contrary, domestic monetary conditions may need to be tightened so as to stem capital outflows.

17 This is also reflected in the ambiguity of central bank mandates on this issue. For example, the Sveriges Riksbank Act requires liquidity provision in the form of extraordinary market operations to be motivated by monetary policy concerns.

Table 1. Liquidity policy tool kit

Tool	Description	Purpose
Intraday credit	• Option for banks to borrow from the central bank during the day	• Smooth functioning of the payments system
Standing facilities/ Discount window facility	• Option for banks to borrow or deposit money overnight in the central bank	• Monetary policy implementation • Smooth functioning of the payments system
Regular open market operations	For example: • Weekly monetary policy transactions (repos/ certificates) • Fine-tuning transactions	• Monetary policy implementation • Smooth functioning of the payments system
Extraordinary open market operations	• Lending or borrowing on different terms than normal, e.g. other maturities, other currencies • Outright purchase/sale of assets in open market	• Monetary policy implementation • Address market wide liquidity shortage • Avert systemic crisis
Emergency liquidity assistance	• Central bank ability to grant credit to individual institution on special terms	• Address acute liquidity shortage at individual institution • Avert spill-overs/contagion

Some of the above tools, such as intraday credit and open market operations are primarily associated with a business-as-usual context, e.g. the practical implementation of monetary policy and the operation of large-value payments systems. Some of the tools could also be expanded, modified or activated to deal with different types of liquidity shortfalls. Other tools, such as ELA, are more exclusively reserved for emergency situations. To understand how the tool kit is devised, it may be of some use to take a look at the mechanics of the payments system and monetary policy steering mechanisms that some central banks have.

3.1 Intraday credit

Many central banks, like the Riksbank, operate a large-value payments system, in which participating banks can carry out payments to each other. Often, central banks provide intraday credit in order to facilitate smooth liquidity management during the day. Such intraday facilities are typically free of interest. Moreover, participating banks need to pledge full collateral to access intraday credit.

3.2 Standing facilities

At the end of the day some banks may find themselves with a surplus and other banks with a deficit vis-à-vis the central bank. To balance out such surpluses and deficits, central banks commonly offer Standing Facilities (SFs) or Discount Window Facilities (DWFs) allowing banks to either deposit or borrow money overnight in the central bank. SFs can be accessed on demand by the central bank's counterparties at a fixed discount rate and against full collateral. In principle, SFs can serve as a means to address temporary problems/malfunctions in the payments system. Furthermore, SFs can function as a form of liquidity insurance, if, for example, an individual institution finds itself with a shortage of central bank liquidity at the end of the day. However, such facilities are often priced at a premium to provide banks with incentives to lend and borrow among themselves rather than to actually use the facilities. This is because the primary function of SFs is not necessarily to provide LA. Instead, SFs are commonly part of the operational framework for implementing monetary policy. Specifically, the interest rate corridor given by the difference between a facility's borrowing rate and deposit rate sets the outer bounds for the overnight interbank rates.

3.3 Open market operations

Apart from standing facilities, central banks also engage in open market lending and borrowing of various kinds. In contrast to standing facilities, open market operations are initiated by the central bank rather than the banks. Typically, some form of a competitive auction mechanism is used for allocating liquidity. Furthermore, central banks can conduct outright purchase and sale of assets in the open market.

One could make a distinction between "regular" and "extraordinary" open market operations (OMOs). Regular OMOs are the transactions used to implement monetary policy, while "extraordinary" open market lending and borrowing can be used more generally to address liquidity shortages of various kinds. Extraordinary OMOs can be particularly useful when the financial market suffers wide-spread shortages of market and funding liquidity, as was the case in the GFC. Extraordinary OMOs can include, for example, temporary liquidity facilities for providing loans to market participants on terms that differ from what central banks offer in their regular facilities. This could be, for example, offering credit with longer maturities, against different collaterals or in other currencies than normal. Moreover, such facilities could also be offered to a broader set of market participants than the normal set of central bank's monetary policy

counterparties. In this sense, open market lending and borrowing is a flexible tool that can be adapted to the needs of the specific situation.

3.4 Emergency liquidity assistance

For circumstances where individual financial institutions are illiquid and lack sufficient eligible high-quality collateral, a central bank may decide to grant ELA to an individual bank by lending against any type of collateral.

An individual financial institution may face critical funding liquidity problems for different reasons. One reason could be general doubts about the solvency of the institution, which may affect the willingness of the institution's counterparties to provide funding. Such doubts need not necessarily be based on actual facts. Sheer rumors may suffice to start a run among depositors and providers short-term funding. In this way, even originally false expectations about an institution's problematic financial situation may become self-fulfilling.

To stop an escalating bank run and contagion to other parts of the financial system, central banks are able to extend ELA to a troubled institution. Provided the institution is eligible for ELA, central banks typically lend against a broad range of collateral. A key criterion in the ELA consideration is whether the institution in question is solvent or not. Furthermore, its systemic importance plays a role. As said earlier, the challenges associated with the solvency assessment and the ELA decision are complex and we will discuss them in Section 4.1.1.

3.5 Liquidity policy and monetary policy instruments

Besides ELA, intraday credit and some specific extraordinary OMOs, all elements of the liquidity policy tool kit presented in Table 1 have to be considered in the context of monetary policy.[18] While regular OMOs are at the core of monetary policy implementation, the distinction between monetary policy and liquidity policy can be blurred when it comes to extraordinary OMOs. Most central banks do not have dedicated facilities for LA.[19] Instead, central banks often extend the scope of their regular facilities for monetary policy implementation, e.g. to provide term liquidity (i.e. liquidity at longer maturities). Such measures may be justified in the context of monetary policy transmission or as element of a system-wide LA. Instead, other measures like foreign currency LA are more clearly distinguishable from monetary policy.

18 See Bindseil (2004) for a discussion of monetary policy instruments.

19 There are few exceptions like the Reserve Bank of Australia and the Bank of England, which we will discuss later on (see also Box 4).

One (potentially imperfect) way to draw a line between liquidity policy and monetary policy is to think of liquidity policy as being aimed at funding liquidity, whereas measures in the realm of monetary policy target asset markets and influence market prices. In other words, liquidity policy addresses liquidity shortfalls by filling a quantity gap and monetary policy aims to reduce spreads with the objective of improving monetary policy transmission.

The existence of contingent extraordinary OMOs via monetary policy instruments or via dedicated facilities for LA is unlikely to have a significant effect on the monetary policy stance in normal times even if the existence of such facilities is known ex ante by market participants. This is because the monetary policy stance primarily aims to steer the risk-free reference rate, which in normal times is not affected by the existence of contingent extraordinary OMOs for LA. On the other hand, the activation of contingent facilities for LA leads to a substantial increase in reserves against illiquid assets and affects the monetary policy stance in crisis times, especially when contingent facilities help to regain control over the risk-free reference rate and spreads in situations where the monetary policy transmission has been impaired. Finally, the existence of permanent dedicated facilities for LA may be associated with a small increase in the level of reserves when the permanent facility is tested in normal times.

The more relevant impact of liquidity facilities on monetary policy derives from the collateral framework used for liquidity policy and the implications for the supply of safe assets. First, the calibration of the collateral framework for the different facilities may impact on the supply of safe assets in the economy and thereby affect the implementation of monetary policy.[20] Second, the calibration of the collateral framework may affect the spread between *high-quality liquid assets (HQLA)* and risky securities such as covered bonds, which has implications for monetary policy transmission and credit allocation. We will highlight these implications as we go along.

4 Challenges for central bank liquidity provision

After laying the foundations in Sections 2 and 3, we are now ready for our discussion of the typical challenges for central banks as public liquidity providers and the trade-offs involved when dealing with these challenges. In this section, we cover challenges arising both during liquidity stress events (Section 4.1) and

20 For instance, a liquidity policy that increases reserves against non-high quality liquid assets can facilitate monetary policy implementation in cases where a binding LCR pushes short-term interest rates to the floor of the rate corridor (Bech and Keister 2013).

in normal times (Section 4.2), which are discussed in the context of the central bank's goals and the liquidity policy tool kit.

4.1 Challenges during liquidity stress events

Different types of liquidity stress give rise to various challenges ranging from difficulties in providing an effective backstop for the financial system (Section 4.1.1), to intricacies of reaching the market participants most in need of liquidity (Section 4.1.2), and problems associated with stigma effects of central bank lending facilities (Section 4.1.3).

4.1.1 Providing a backstop: solvency assessment and communication

As described in Section 2, it is well known that uncertainty about the solvency of individual financial institutions constitutes a core challenge to LA. In an idiosyncratic stress event, i.e. where liquidity problems arise at a single institution, the difficulties associated with the solvency assessment are most pronounced in a setting where a central bank provides ELA to an institution that does not have sufficient collateral. Notably, the counterparty's creditworthiness may also depend on domestic and foreign authorities' supervisory or legal actions. During system-wide liquidity stress, assessing the solvency of an individual institution is exacerbated by the difficulty in evaluating the quality of illiquid assets that may be used as collateral for central bank liquidity. Such a difficulty arises if the availability of HQLA in the private sector falls short of the liquidity demanded by individual institutions. Furthermore, the need for a timely response may also conflict with the necessities of a careful solvency assessment. In such a situation, the outright purchase of assets in the market may have the advantage over bilateral LA that it does not require a solvency assessment for individual institutions.

In normal times, market valuations and ratings provide important guidance for the formulation of central bank collateral policies. However, during periods of massive systemic stress, such as at the onset of the GFC, this guidance is lost because private-sector collateral values are negatively affected by distress in financial markets, for instance due to harmful liquidity spirals (Brunnermeier and Pedersen 2009). As a result, the assessment of central banks who act as a MMLR during a systemic liquidity stress event may entail a stronger emphasis on the collateral values that would prevail in normal times (Mehrling 2012), as opposed to crisis-times market valuations. In this way, LA can contribute to stabilizing core collateral values that are affected by asset fire sales and contagion effects. Such a policy response, however, creates tensions due to the elevated risks for central bank balance sheets.

Besides the solvency assessment, central bank communication comprises important challenges. Only central banks are in the position to provide a backstop and to re-establish market confidence during a crisis by assuming their role as LLR. Important factors to this end are the central bank's institutional preparedness for dealing with stress scenarios and its ability to display and communicate a credible policy response and to perform rapid solvency assessments. Another challenge may be to adapt the degree of transparency about the available tools and lending terms without compromising the flexibility for policy going forward. Again, the GFC serves as an illustration, where central banks replaced constructive ambiguity with more explicit communication about available policy options and lending terms (Domanski et al. 2014) in order to fight against a crisis of confidence.

4.1.2 Reaching the market participants most in need of liquidity

Another key concern for central banks is reaching the market participants in need of liquidity. At the onset of the GFC, it became evident that existing frameworks for LA were not prepared for a global systemic stress event on such a massive scale, but were rather calibrated to deal with idiosyncratic stress events (see Section 2.4). As a result, central banks faced obstacles in extending the scope and reach of LA.

Reaching the market participants most in need poses challenges with respect to the location and type of liquidity demands. The location of a liquidity need in the financial system matters especially when banks are reluctant to provide liquidity to one another. Central banks conduct their regular lending operations only with a limited circle of counterparties. Hence, central banks may face obstacles in achieving the desired distribution of liquidity in the financial system in times of systemic stress when the banking system fails to intermediate the liquidity provided by the central bank to eligible counterparties. This issue proved to be an important obstacle to central bank LA during the GFC and we discuss in Section 5 how it can be dealt with.

The GFC also uncovered challenges related to the type of liquidity need. Existing frameworks for LA typically focused on liquidity support at short maturities, against highest-quality collateral and in domestic currency. This created discrepancies between the prevalent liquidity demand and the supply of liquidity by central banks along several dimensions. The drastic shortening of funding maturities in markets caused a demand for longer-term funding from central banks by financial institutions. Similarly, the dry-up of funding backed by less liquid assets generated a rational for LA against a broader range of collateral and, in some markets, for the support of collateral values. A number of jurisdictions with domestic banks reliant on foreign currency funding, such as Sweden, also experienced a discrepancy between liquidity demand and supply

in the currency dimension, which central banks addressed by lending in foreign currency. Taken together, the crisis response was characterized by providing LA to a broader circle of counterparties at the required maturities against a broader set of eligible collateral, and in the required currencies.

To summarize, both the location of liquidity needs and potential discrepancies between the liquidity demand and the type of liquidity supplied by central banks can pose challenges in reaching the market participants in need with the available tools and procedures. In the next section, we discuss why the stigmatization of central bank lending facilities poses an important obstacle in reaching the market participants most in need of liquidity.

4.1.3 The problem of stigma

Stigma may impair the functioning of several elements of central banks' lending facilities that are important for the effectiveness of the LA framework.

> *"[The problem of stigma is associated with a concern of financial institutions] that their recourse to [certain central bank lending facilities], if it became publicly known, might lead market participants to infer weakness"* (Bernanke 2009, p.3)

This concern originates from an adverse selection problem[21] and can impair the participation in and, hence, the functioning of central bank facilities.

During the GFC, the problem of stigma posed a significant challenge. We first discuss some anecdotal evidence that underpins the relevance of the problem of stigma. Thereafter, Box 1 summarizes the empirical evidence for the stigmatization of central bank lending facilities and reviews the theoretical underpinnings.

In August 2007, the U.S. dollar money market was abruptly disrupted. Despite a lowering of the discount window rate and the spread over the Federal Funds rate,[22] financial intermediaries were reluctant to borrow from the Federal Reserve (Fed). As a consequence, the Fed's efforts to improve funding liquidity showed limited success. To address this problem, the Fed introduced the new Term Auction Facility (TAF) alongside the Discount Window Facility (DWF) in December 2007. While the DWF is a standing facility where liquidity is provided on demand

21 The term "adverse selection" was originally used in insurance. It describes a situation where an individual's demand for insurance is positively correlated with the individual's risk of loss.

22 The spread over the fed funds rate was reduced from 100 basis points in July 2007 to 50 basis points in August 2007 and to 25 basis points in March 2008.

at a fixed discount rate, the TAF is an open market operation using a competitive auction mechanism.[23]

Also the effectiveness of the Bank of England's lending facilities was impaired by stigma (Bank of England, Winters Report 2012). In part, this can be attributed to the penalty rate for lending from the DWF. However, it was also problematic that information on the DWF activity was prone to rapid leaks to the media. Following such a leak on the evening of September 13, 2007, for example, the BBC reported that Northern Rock was to seek access to emergency liquidity via the Bank of England's DWF on September 14. This has been seen as instrumental in its failure. In the words of Mr. Applegarth, CEO of Northern Rock at the time:

> *"[On September 13] we were actually still funding — not fully funding, and duration was noticeably shorter, but we were still funding. …[We] had two or three months' worth of liquidity. ...The problem we had was you could not tell how long the markets were going to be closed and it was a reasonable and proper thing to do to put a backstop facility in place. …Ironically, it was the announcements and the leaking of the backstop that caused the retail run and it was the retail run that reduced our liquidity."* (House of Commons Treasury Committee 2008, p. 17)

This statement highlights how stigma can hamper central banks' ability to provide liquidity. Whenever wholesale or retail investors have some residual uncertainty about the effectiveness of the backstop provided by the central bank[24] or fear of being diluted by more senior claims of central banks, then investors may have an incentive to withdraw after learning about discount window activity. Given that troubled banks know about the risk of a media leak when requesting access to the DWF, they may want to delay a request and see if they can manage their problems differently without having to rely on the LLR. From the viewpoint of a liquidity provider or a regulator, such a delay may not be desirable and socially costly for at least two reasons. First, the troubled bank cannot fulfill its role in providing private liquidity to its customers and, second, ELA at a later point in time is likely to require the central bank to assume a higher credit risk.

23 In Section 5 we will discuss in more detail how OMOs can help to deal with the problem of stigma and other obstacles in reaching the market participants most in need of liquidity.

24 For instance due to a lack of credibility in the backstop for operational or legal reasons.

BOX 1 – Stigmatization of central bank lending facilities

Evidence Armantier et al. (2011) provide empirical evidence for the willingness of banks to pay a premium of 44 basis points on average in TAF auctions from March 2008 onwards to avoid borrowing from the Fed's DWF, which increased after the Lehman bankruptcy to 143 basis points. The magnitude of stigmatization of the DWF was substantial. It amounted to a deliberate increase in the banks' borrowing costs by up to 32.5 percent of their net income during the crisis, in order to avoid accessing the stigmatized standing facility.

In the Eurozone, the stigmatization of the European Central Bank's (ECB's) lending facilities was less severe, because the usage of the ECB's standing facility, the marginal lending facility, was less rare in normal times than the usage of the Fed's DWF. Nevertheless, there is evidence that the ECB lending facilities may also have experienced some stigmatization. Cassola et al. (2013) find that banks were willing to borrow at average premia of up to 30 basis points over the average overnight unsecured interbank lending rate (EONIA) via the ECB's regular Main Refinancing Operations (MROs) by the end of 2007, which indicates a stigmatization of the ECB's marginal lending facility.

Theory The stigma is associated with a classical adverse selection problem (see, for instance, Ennis and Weinberg 2013). It arises if banks have favorable private information on the quality of the assets on their balance sheet, which they cannot signal to the interbank market. In such a setting the recourse to the central bank's DWF, if observed by other market participants, can impair a bank's ability to obtain market funding. This is because other market participants then believe that the bank's assets are likely to be of bad quality even if the unobserved quality is good. As a result, the behavioral response of an individual bank with severe liquidity problems is to try to avoid recourse to the DWF. La'O (2014) argues in a model with predatory trading that a term auction facility with a competitive auction format, such as the Fed's TAF, may be an effective policy tool in crisis times. TAF provided liquidity through a competitive auction format, which was designed in a way as to create an outcome where the winning bidders are the ones with the highest financial strength. In this way, and different to the DWF, TAF achieves a high level of participation.

4.2 Other challenges

Alongside the challenges encountered during episodes of idiosyncratic or systemic liquidity stress, the regular conduct of liquidity provision also involves relevant challenges from the viewpoint of central banks. We next discuss the availability and pricing of central bank lending facilities more generally, as well as collateral frameworks and the exit from LA.

In their regular conduct of liquidity provision, central banks have the objective to encourage private liquidity provision against a broad set of collaterals and to achieve an appropriate distribution of liquidity (see Section 2.4), which is considered to play an important role as a lubricant for the financial system. Hence, central banks face a balancing act between the availability of public liquidity and the dangers from crowding-out private liquidity. While lending more freely may have a positive and supportive effect on private liquidity provision and help the central bank to obtain valuable market information through regular liquidity operations, it may also be associated with an impairment of private liquidity provision. Furthermore, the reliance of financial institutions on private liquidity provision is frequently associated with a positive market disciplining effect since peer monitoring can reduce moral hazard problems (see Section 2.2). For this reason, the availability and pricing of liquidity provided by central banks plays an important role.

The pricing and haircuts of central bank collateral frameworks can be associated with distortions in credit allocation. Traditionally, sovereign debt is an important source of HQLA for central bank refinancing operations. Since central bank liquidity operations can have an effect on secondary market prices (Chapman et al. 2011; Ashcraft et al. 2011), preferential treatment of sovereign debt or other types of debt like covered bonds in central bank collateral frameworks may have wider implications for credit allocation in the economy. Hence, eligibility of certain types of collateral and haircuts play are important policy choices that feed back to markets and influence credit and investment decisions.[25]

During and after the GFC, it became apparent that liquidity problems of individual financial institutions or certain parts of the financial system can persist for several months or years (Dobler et al. 2016), with institutions relying on LLR LA over an extended period. Such a scenario occurs, for instance, when central banks, due to financial stability concerns, are reluctant to adjust the pricing of liquidity in a way that would facilitate an exit from LA. This poses additional challenges for central bank balance sheet risk management and may impair market discipline.

25 In Section 6 we discuss in detail the trade-offs for liquidity provision stemming from collateral frameworks and their impact on the credit allocation, market discipline, and the central bank balance sheet risk management.

5 Dealing with the challenges

In this section we discuss ways to deal with some of the challenges for central bank liquidity provision discussed so far in the context of the central bank policy tool kit (Table 1). Again most of the discussion is framed against the backdrop of the GFC. The focus is on central bank policy responses during the crisis. A key avenue in addressing challenges related to idiosyncratic and systemic stress scenarios is to consider a broadening of the scope of liquidity provision along different dimensions. We continue by discussing in Section 5.1 how some central banks attempted to provide a backstop to the broader financial system by dealing with a shortage of private sector collateral. Thereafter, Section 5.2 discusses how the reach of central bank LA can be improved by broadening LA along certain dimensions. Finally, Section 5.3 discusses elements of the standard policy tool kit that may be prone to stigmatization as well as modifications to central bank lending facilities to overcome the problem of stigma.

5.1 Dealing with a shortage of egligible collateral

The scarcity of unencumbered collateral held by the private sector during the GFC was addressed by several central banks by, at least temporarily, relaxing their collateral requirements, in particular, for their most effective instrument of LA, the open market operations. Furthermore, it was made easier to pledge certain mortgage-loan and non-mortgage loan portfolios, as well as non-marketable collateral. The *market-wide* or *systemic* shortage of private sector collateral to a large extent also required *market-wide* LA. As discussed in Section 2, the supply of public liquidity to markets is distinct from the supply of funding for individual institutions. LA to certain markets is aimed at supporting core collateral values of financial institutions by means of an outright purchase of assets and repurchase agreements. Such an intervention may be warranted if the intermediation of liquidity to the wider financial system comes to a halt and collateral values are undervalued due to asset fire sales and harmful liquidity spirals. In 2007-2009, the Federal Reserve acted as such a *dealer-* or *market-maker-of-last-resort* by supporting collateral values of core assets that were important for the functioning of the dealer-based financial system.

While most of the modifications to central bank lending facilities have been discontinued after the GFC, some modifications prevailed. For instance, some central banks officially introduced contingent or so-called dormant, facilities in their liquidity frameworks in order to have them available in the event of severe liquidity shortages in the financial system. Alongside other modifications, the Bank of England introduced a Contingent Term Repo Facility, which is designed to

be activated in response to a market-wide stress scenario. In Box 4 at the end of Section 5, we give some details on the new Bank of England liquidity insurance framework. Another example is the Bank of Canada, which also introduced a Contingent Term Repo Facility. The Bank of Canada sees this new facility as part of its flexible operating framework that allows for the contingent provision of overnight or term-funding beyond primary dealers (Bank of Canada 2015). Moreover, the Bank of Canada also foresees contingent relaxations to the collateral requirements that can be activated in periods of financial distress. The standing facility of the Bank of Canada has now a clause that allows it in crisis times to fully lift the requirement that only 20 percent of the pledged collateral can consist of Canadian-dollar non-mortgage portfolios.

5.2 Adjusting liquidity assistance to changing needs

As mentioned previously, a specific challenge related to the fact that some of the market participants most in need of liquidity were several steps away from the circle of ordinary central bank counterparties and, hence, severely affected by the banks' reluctance to provide liquidity to each other. To address this problem, some central banks widen the circle of eligible counterparties during and after the GFC. The most prominent example of extending the reach of central bank LA at the beginning of the crisis was the granting of a bank holding company license to Goldman Sachs and Morgan Stanley. This occurred over a single weekend after the Lehman failure in September 2008 and gave the broker-dealer subsidiaries of the two investment banks access to the Fed's Primary Dealer Credit. Notwithstanding, the small circle of counterparties for OMOs, together with the stigmatization of the DWF, severely limited the reach of the Fed's LA during the crisis.[26] The Fed responded by creating the TAF, which offered funding to a wider set of counterparties. The auctions for credit at longer maturities were each accessed by around 50-90 banks.[27]

Other central banks have taken similar initiatives to widen the circle of eligible counterparties during and after the crisis. For example, the Bank of Canada introduced in April 2008 the Overnight Standing Purchase and Resale Agreement facility for primary dealers as a complement to the standing facility, which is only available for participants in the Large Value Transfers System. This newly

26 Notably, the counterparty arrangements differ substantially across jurisdictions (see Table 1 in Chailloux et al. (2008)). At the time of the GFC, the Federal Reserve granted direct liquidity assistance to around 7,500 credit institutions via the standing facility, while only 20 primary dealers could participate in open market operations. This contrasts with the counterparty arrangement of the ECB where 2,400 credit institutions participated in the standing facility and 1,700 banks participated in open market operations. In the Eurozone, the creation of a new facility was not necessary since the ECB was able to provide liquidity through its MRO to a large number of banks.
27 See archive section of http://www.frbdiscountwindow.org.

introduced facility effectively widened the access to the Bank of Canada's SF and was kept in place after the GFC. More recently, the Bank of England responded by permanently extending the circle of eligible counterparties to include, e.g. market infrastructures.

Besides the attempts of central banks to deal with the location of liquidity demand by widening the set of eligible counterparties, the type of liquidity demand in terms of maturities and currencies also played an important role during the GFC. In Sections 5.2.1 and 5.2.2 we discuss how these two issues can be dealt with in the context of the central bank policy tool kit.

5.2.1 Liquidity assistance at longer maturities

In normal times, central bank liquidity is offered almost exclusively at short maturities of one week or less. Most of it occurs via central bank reserve management and fine-tuning operations. This picture changed drastically during the GFC when financial institutions had difficulties raising the desired term-funding from U.S. dollar money markets. As a result, there was a high demand for term-funding provided by central banks. Thus the Fed, the ECB and others started to offer funding at longer maturities via OMOs. For instance, TAF funding was offered at 4 week maturities starting in December 2007 and then extended to 12 weeks in August 2007. Similarly, other central banks also provided term-funding at maturities up to 6 month or more.

From a conceptual viewpoint, it may not be immediately obvious why central banks did not just continue to provide liquidity at shorter maturities in the required amounts and against a wider range of collateral. In principle, a commitment to extend the availability of sufficient short-term funding should suffice to provide a credible backstop to the financial system. However, the ample supply of term-funding at longer maturities is perhaps the most effective way to eliminate any concern by financial intermediaries with an elevated maturity mismatch that extraordinary LA (and the terms thereof) may only be temporary. Furthermore, the provision of term-funding may reduce the need for potentially problematic public announcements by central banks that promise cheap liquidity over a longer time horizon and, thereby, increase flexibility.

5.2.2 Liquidity assistance in foreign currency

During the GFC, the importance of LA in foreign currency also became accentuated. This was largely dealt with through various OMOs. In this section, we first review extraordinary lending in USD by major central banks during the crisis and the reasons underlying the necessity of such an intervention. Thereafter, we

discuss the implications for today's LA and the emergence of regular USD facilities operated by some European central banks.

After the failure of Lehman, the Fed spearheaded a coordinated crisis response by major central banks with the help of *central bank currency swaps* - a foreign exchange (FX) derivative that is used by central banks to provide liquidity in their own currency to one another. In December 2007, the Fed established swap lines with the ECB and the Swiss National Bank over 24bn USD. During 2008 the swap lines were massively extended. They developed into a swap network after the Fed established further swap lines with the Bank of Canada, Bank of England, Bank of Japan, Sveriges Riksbank, Reserve Bank of Australia, and others.[28] Eventually, the total authorized amount grew to nearly 620bn USD. Box 2 gives a summary of the recent history of central bank currency swap lines.

The case of Sweden is well-documented (Goodhart and Rochet 2011; Bryant, Henderson and Becker 2012) and serves as an illustrative example of how market-wide emergency liquidity support in foreign currency can be engineered. In Sweden, "the basic problem [during the crisis] was one of liquidity, in particular a shortage of foreign currency, especially USD, liquidity" (Goodhart and Rochet 2011, p. 19). In fact, more than half of the liquidity assistance provided by the Riksbank in 2007 and 2008, as depicted in the expansion of the Riksbank's balance sheet in Figure 3, was in USD. Box 3 gives a detailed account of the Riksbank's emergency dollar lending.

While the Riksbank and most other central banks discontinued the USD liquidity assistance in 2009 after the crisis started to abate, a group of major central banks with globally systemically important banks in their jurisdictions established regular lending facilities in USD. Specifically, the Bank of Canada, the Bank of England, the Bank of Japan, the ECB, and the Swiss National Bank now conduct regular USD repos. Prior to May 2014, USD funding was offered at 3-month maturities, which was then reduced to 1-week maturities. This USD lending is facilitated by swap agreements with the Fed. The intended purpose is to improve the resilience of global U.S. dollar money markets and to mitigate financial distress by providing a timely access to USD for globally important banks. Notably, the Bank of Japan also has a number of bilateral swap agreements with other central banks in the region.[29]

Looking ahead, swap agreements remain an important pillar of global financial stability and the actual usage thereof typically has to be approved ad hoc.

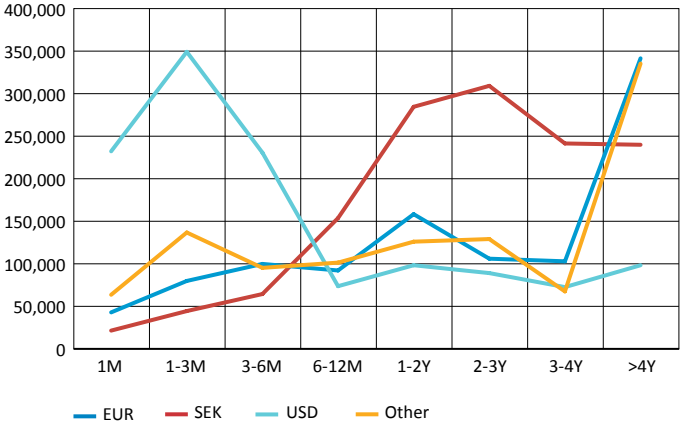
28 See Goldberg et al. (2011) for a review of the Fed's swap lines during the financial crisis. For an up to date list of currency swap arrangements see: http://www.cfr.org/international-finance/central-bank-currency-swaps-since-financial-crisis/p36419#!/?cid=from_interactives_listing.

29 http://www.boj.or.jp/en/intl_finance/cooperate/index.htm.

Traditionally, swap lines have been triggered by the need for bilateral LA to an individual institution, but the use of swap lines for LA to the market via OMOs can also become relevant.

For the case of Sweden, the reliance of Swedish banks' on foreign currency funding remains an important factor. Of the total funding of the four major Swedish banking groups, wholesale funding accounts for approximately 50 percent, of which some three quarters consist of funding in currencies other than SEK. This can be seen in Figure 4, which depicts the maturity and decomposition of the average outstanding funding volume in the money and bond market by the four major Swedish banks in 2015. Notably a large part of the outstanding funding volume with a time till maturity below one year consist of money market instruments, such as certificates of deposit and commercial paper.

Figure 4. Duration and currency decomposition of the outstanding funding volume by the four major Swedish banking groups
(Mio. SEK, 2015 averages excluding bail-in debt)



Source: The Riksbank

In the money market (maturities below 1 year), USD is the dominant funding currency, while SEK and EUR play more important roles as funding currencies in the bond market (maturities above 1 year).[30] Absent a swap agreement with the Fed, this poses a potential challenge for the management of future shortages of funding liquidity. "A way to minimize the risk is for the Riksbank to maintain a foreign currency reserve" (Nyberg 2011, p. 10), which can be seen in Figure 3.

30 See Hilander (2014) and Juks (2015) for detailed studies.

Box 2 – FX swap lines during the crisis

While central banks could provide unlimited LA in their domestic currencies during the crisis, their ability to provide liquidity in foreign currency was limited by the amount of foreign currency reserves they held. To address this problem, many swap lines were set up between central banks.

U.S. dollar swaps In particular, the demand for USD increased among European banks during the GFC, resulting in heightened volatility in U.S. interest rates. In December 2007, the Fed extended swap lines to the European Central Bank (ECB) and the Swiss National Bank (SNB), allowing the Fed to address stress in the short-term funding markets without having to fund foreign banks directly.

Soon after the collapse of Lehman Brothers in September 2008, the Fed expanded the size of its swap lines with the ECB and SNB, and extended new swap lines to Bank of Canada, Bank of England and Bank of Japan. Following shortly after this, the Fed extended further swap lines to the central banks of Australia, Denmark, New Zealand, Norway, and Sweden.

During the course of the crisis, some central banks also provided swap lines to certain economies, in which intensification of stress would risk triggering unwelcome spillovers to the rest of the world economy. For example, the Fed extended swap lines to Brazil, Mexico, Singapore, and South Korea in October 2008 with such considerations in mind.

Euro zone The ECB established swap lines with the Riksbank in December 2007. In October 2008, the ECB launched additional swap lines to the SNB and Danmarks Nationalbank. In the years leading up to the crisis, both Swedish and Danish banks funded themselves to a large extent in foreign currencies. In 2008, this source of funding became increasingly unreliable. However, the FX reserves in Sweden and Denmark proved insufficient to meet the increased demand for foreign currency when the banks subsequently turned to the central banks for assistance. In 2009, the ECB swap lines were therefore called upon to provide the Riksbank and Danmarks Nationalbank with euros (EUR). At about the same time, the ECB called into use its swap line with the SNB to provide the ECB with Swiss francs (CHF). In December 2010, the ECB also established a swap line to the Bank of England. It was put in place primarily as a precautionary measure to ensure that the Central Bank of Ireland would have access to pounds sterling (GBP), but was never called into use.

Swiss francs and euros to Poland, Hungary and Latvia Before the outbreak of the crisis, many households in countries such as Poland and Hungary had taken

out foreign-currency-denominated mortgages because of the lower interest rates available on these loans. During the crisis demand for CHF and EUR from the Hungarian and Polish banks that issued the loans drove up borrowing costs in these currencies. In response to this, the SNB provided CHF through swap lines to the central banks of Poland and Hungary Moreover, the ECB agreed to provide EUR to Hungary, Latvia, and Poland. Initially EUR was only provided through repurchase agreements, in which bonds rather than currency are held as collateral, but eventually the ECB extended a normal swap line to Hungary.

Nordic countries During the GFC, Scandinavian central banks provided some swap lines in EUR to neighboring countries to support financial stability in the region. For example, the Riksbank agreed to provide EUR to the central banks of Latvia, Estonia, and Iceland. Danmarks Nationalbank provided EUR to the central banks of Iceland and Latvia, and Norges Bank provided EUR to Iceland. This bilateral cooperation was established to avoid negative spill-overs during the crisis, because circa 80 percent of the Latvian and circa 90 percent of the Estonian banking system is owned by banking groups headquartered in Sweden, Norway, and Denmark. Moreover, Nordic countries provided Iceland with 2.5bn USD in loans to Iceland during the crisis. This and the swap lines provided could be seen as a natural complement to the cooperation with Sweden, Norway, and Denmark through the Nordic Council, an inter-parliamentary body in place since 1952.

Box 3 – The Riksbank's emergency USD lending

Conduct The Riksbank's USD lending to a number of Swedish intermediaries started in the weeks after the Lehman bankruptcy and the first auctions took place in October 2008, culminating in a monthly peak volume of 30bn USD in May 2009. Before the swap lines with the Fed were in place, the Swedish lender-of-last-resort crisis response was backed up by the foreign currency reserves of the Riksbank and, importantly, by the cooperation of the Swedish National Debt Office. In fact, as early as October 2007, the Swedish National Debt Office issued debt in foreign currency and guaranteed some of the borrowing activity of Swedish banks in USD. This lending in foreign currency was accompanied by liquidity provision in Swedish kronor (SEK) and by cuts in the repo rate.

Underlying reasons The necessity to provide extraordinary liquidity assistance in foreign currency arose because the Swedish banking system and, in particular, the four largest banks relied heavily on funding from U.S. dollar money market. This short-term wholesale funding was used to fund assets denominated in foreign currency, but also to fund SEK assets. "The Swedish banking system had, like many others, increased its credit expansion much faster than its (domestic) deposit base; indeed it had done so somewhat faster than in many other countries… The withdrawal of short-term USD (and to a lesser extent EUR) funding was particularly acute for those European banks whose solvency was thought by the market to be at risk. In the Swedish case this was particularly so for the two banks with substantial lending operations in the Baltics, Swedbank and SEB." (Goodhart and Rochet 2011, p.19-20).

5.3 Facilities prone to stigmatization and ways to mitigate the problem

In the light of the evidence discussed in Section 4.1.3, it is apparent that standing facilities (discount window; marginal lending facility) and ELA are most prone to stigma. For the example of Sweden, SFs are designed in a way that discourages from active usage not only because of the pricing, but also due to the small market size which makes it close to impossible to keep a rare activity of the Riksbank's on-demand facility secret.[31] Although the pricing of SFs may indeed affect the magnitude of the stigma, in some circumstances banks seem to be willing to go to considerable lengths to avoid public liquidity support (see Box 1).

However, ad-hoc contingent open market operations may also be stigmatizing if individual banks refuse to participate, because this creates a situation of a dis-advantageous selection. This concern is especially relevant in an environment with a small number of eligible financial institutions where the abstention of few individual banks can create a stigma for their peers who may want to participate.

One way to mitigate the problem of stigma is to make the use of central bank facilities more commonplace and less dramatic. More regular participation in central bank facilities in normal times could possibly alleviate some of the stigma. This is one of the objectives of the Bank of England's recently modified liquidity insurance concept and especially the so-called *Indexed Long-Term Repo* (ILTR) facility, which foresees the provision of term-liquidity also in normal times and allows for a dynamic adjustment of the liquidity supplied by the central bank if warranted. We describe the ILTR facility in more detail in Box 4.

More generally, the regular participation of a wider circle of counterparties in certain lending facilities reduces the likelihood of disadvantageous selection. Open market operations are a flexible policy tool to address these objectives. Specifically, an acute stigmatization of lending facilities can be dealt with by tailoring the terms and conditions of regular OMOs or by introducing newly designed OMOs. The former approach was taken by the ECB via the extension of its regular OMOs, while the latter approach was taken by the Fed via the introduction of the new Term Auction Facility (see Box 1). In principle, the pricing and haircuts of central bank lending facilities can be made attractive enough to encourage a large number of market participants to participate, thereby minimizing the stigma. Such an approach, however, is likely to come with some drawbacks that we discuss in Section 6.

Besides the broadening of the scope of liquidity provision by extending open market operations, a further way of reducing stigma would, in principle, be to

31 See Selin and Åsberg Sommar (2014).

restrict the disclosure of the actual use of liquidity facilities. For instance, in the U.S., the Fed discloses under the Dodd-Frank Wall Street Reform and Consumer Protection Act (2010) the detailed discount window activity only with a lag of two years. While this may help to limit the problem of stigma, other elements of the Dodd-Frank Act introduce reporting requirements that heighten "borrowers' concerns that the public, their creditors, or their counterparties could learn about their borrowing and conclude that the bank is in trouble" (Fisher 2016, p. 11). Irrespective of such legal constraints, a lesson from Northern Rock is that it may in practice not be easy to cover up the use of e.g. SFs, in particular in a small system such as the Swedish one.

Finally, another relevant aspect when attempting to conduct discreet LA is to allow financial institutions to borrow HQLA instead of reserves from the SF, as is the case for Bank of England's DWF, for example (see Box 4). In this way, LA is potentially less likely to be detected. This is because the increase of reserves in a closed system inevitably implies that other banks will end up with higher reserves and notice that another bank has received LA. In many institutional settings as well, an increase of reserves may show up faster in public statistics than the lending of HQLA. Moreover, an advantage of lending HQLA is that it allows the central bank to also provide LA to a financial institution that is not part of the large-value payment system without having to rely on a correspondence bank. Lastly, foreign currency LA also can be provided in the form of lending foreign currency denominated HQLA as opposed to foreign currency cash.

Box 4 – The Bank of England's Sterling Monetary Framework

Facilities in the published framework The Bank of England (BoE) offers some facilities for liquidity provision in the normal course of implementing monetary policy. The BoE's reserves averaging (currently not in use) and Operational Standing Facilities are both primarily designed to keep overnight market interest rates in line with the central bank's policy rate. At the same time, these facilities may serve as a means to manage unexpected frictions in the payments system due to, e.g. technical problems. Like other central banks, the BoE also provides intraday liquidity to ensure smooth functioning of the payments system. In light of its experience from the GFC, the BoE has also developed three facilities for the explicit purpose of *liquidity insurance*– the Indexed Long-Term Repo, Discount Window Facility and Contingent Term Repo Facility. *Transparency* The BoE lays down a high-level strategy for its role as LLR. While the information about the non-crisis framework is published in detail, the information about ELA is restricted to some guiding principles. Moreover, the BoE is ex-ante transparent about the existence of contingent facilities and the high-level strategy for the use thereof.

Indexed Long-Term Repo The BoE offers funds with a *6-month maturity* via an Indexed Long-Term Repo operation *once each calendar month. Counterparties* The operations are aimed at banks, building societies and broker-dealers with a predictable need for liquid assets. *Collateral* Eligible counterparties are able to borrow against three different sets of collateral, levels A, B, and C.[32] *Pricing* The rate charged in ILTR lending is indexed to the BoE policy rate, so participants do not have to take a view on the future path of the rate. It also allows the BoE to reduce its exposure to market risk.[33]

Discount Window Facility The DWF is a bilateral on-demand facility. It is aimed at institutions experiencing a firm-specific or market-wide shock. It allows participants to borrow HQLA (gilts) in return for less liquid collateral in potentially large quantities and for a variable term. *Counterparties* The DWF is available

32 Level A = certain high-quality highly, liquid sovereign securities; Level B = high-quality liquid collateral, including other sovereign, supranational, mortgage and corporate bonds; Level C = less liquid securitizations, own-name securities and portfolios of loans.

33 Participants bid by submitting a nominal amount and a spread to Bank Rate expressed in basis points against a specific collateral set. The auction is designed to provide some flexibility with regard to the total quantity of funds being made available and the proportion of funds that is lent against a particular set of collateral. The mechanism depends on the interaction of the demand for funds, shown by the pattern of bids received, and the BoE's preferences for supplying funds.

to banks, building societies, broker-dealers and Central Counterparty Clearing Houses (CCPs). *Collateral* Banks, building societies and broker-dealers are able to borrow gilts in the DWF against the full range of eligible collateral, while CCPs may only borrow against Levels A and B collateral. Participants can raise cash by lending the gilts in the market or by using them as collateral in the ILTR for example. *Pricing* The DWF fees charged are set at a premium to the market in routine circumstances but should offer participants affordable liquidity in less normal conditions.[34]

Contingent Term Repo Facility The Contingent Term Repo Facility (CTRF) is a (dormant) liquidity facility that the BoE can activate in response to market-wide stress of an exceptional nature. *Counterparties* The CTRF enables the BoE to provide additional sterling liquidity to banks, building societies and broker-dealers. *Collateral* The BoE lends against the full range of eligible collateral, comprising Levels A, B and C. *Pricing* Participants bid by submitting a nominal amount and spread to Bank Rate.[35]

The BoE's Sterling Monetary Framework is published in the Red Book on the BoE's website: http://www.bankofengland.co.uk/markets/Pages/sterlingoperations/redbook.aspx

34 The fee reflects the type of collateral used, to avoid providing a subsidy for illiquid collateral relative to the market, and the size of the drawing, to incentivize repayment when borrowings are no longer needed. For broker-dealers and CCPs, the cost of drawing in the DWF will be agreed with counterparties on a bilateral basis at the time of drawing, to reflect the collateral used and the size of the drawing. The BoE may lend sterling cash instead of gilts if, for example, government bond repo markets do not function properly. The BoE will lend sterling cash to CCPs in the DWF as standard. DWF drawings by banks, building societies and broker-dealers have a maturity of 30 days, while drawings by CCPs have a maturity of five days. All drawings are repayable at any point. Eligible collateral should be delivered or pre-positioned at least a day before a drawing. Participants are strongly encouraged to keep sufficient eligible collateral at the BoE at all times to ensure they are able to draw in from the DWF quickly should the need arise. Participants considering use of the DWF are strongly encouraged to discuss this with the BoE at an early stage.

35 The auction's pricing mechanism uses a so-called 'uniform price' format, in which all successful bidders pay the lowest accepted spread (the 'clearing spread'). The BoE indexes the rate charged to Bank Rate and would expect collateral used in CTRF operations to have been delivered or pre-positioned.

6 Pitfalls and trade-offs for public liquidity provision

In this section, we discuss the trade-offs related to dealing with the challenges to LA described previously. While there are unambiguously positive effects of public liquidity provision on the behavior of financial institutions though the LLR's contribution to the resilience of the financial system (as discussed in Section 2), there are also a number of behavioral aspects that may be associated with negative or unintended implications. Section 6.1 discusses these behavioral aspects and ways to mitigate them. Thereafter, Section 6.2 addresses the risks to central bank balance sheets and ways to manage these risks with a focus on collateral frameworks. Then Section 6.3 discusses issues related to the monetary policy dimension of liquidity provision. Finally, Section 6.4 summarizes key trade-offs going forward.

6.1 Ways to mitigate unintended behavioural implications

We first highlight in more detail the unintended behavioral aspects and then discuss how these aspects can be dealt with, so as to achieve the goals of a central bank as public liquidity provider outlined in Section 2.4. The most relevant negative or unintended behavioral aspects related to public liquidity provision are a potential impairment of both private liquidity provision and market-discipline, leading to risk-taking, as well as to distortions in credit allocation.

As outlined in Section 2.2, public and private liquidity supply are not perfect substitutes. Without any regulatory intervention, an increase of public liquidity supply in normal or in crisis times is likely to crowd-out the private liquidity supply. This crowding-out effect arises because individual financial intermediaries have less incentive to maintain costly liquidity buffers consisting of reserves and other HQLA when a central bank provides liquidity against a wide range of securities. The crowding-out of private liquidity may in principle be beneficial if it allows financial intermediaries to freely channel resources to illiquid long-dated real investments without creating other distortions. Such distortions or costs may, however, arise when private liquidity provision is positively associated with the financial system's resilience against adverse shocks or if it facilitates LLR operations such as the ELA solvency assessment (Santos and Suarez 2016). In addition, private liquidity provision may play an important role when it comes to the merits of *market discipline*, or more generally, to curtail *risk-taking*. Specifically, public

liquidity provision may have adverse behavioral implications if it facilitates higher risk-taking in the financial sector due to *moral hazard*.

The use of wholesale short-term funding can have advantages, as it helps to smooth out unexpected liquidity needs resulting from drawn credit lines or retail deposit withdrawals. Furthermore, short-term wholesale funding may play a role in enhancing market discipline, because lenders can monitor banks and refrain from rolling over debt when banks engage in risky lending activities (Calomiris and Khan 1991).[36] Thus, a crowding-out of private liquidity provision by public liquidity may have unfavorable implications in terms of reduced market discipline. On the other hand, a policy of restrictive liquidity provision during normal times, combined with a policy of very expansive LLR LA during crisis times, may incentivize market participants to build up an over-reliance on short-term funding during normal times that may prove harmful in crisis times. In the extreme, an expansive public liquidity backstop may create perverse incentives that undermine solvency and give rise to financial turbulence (Haltom and Lacker 2014).

The so-called *too-big-to-fail* problem plays an important role in this context. Large and inter-connected individual institutions may not behave prudently, knowing that the LLR or government will assist in case of liquidity and solvency problems, in order to prevent adverse system consequences. This type of *collective moral hazard* differs from the previously discussed moral hazard problems in the context of private liquidity systems (see Section 2.1). Fahri and Tirole (2012) and Keister (2016) argue that the maturity transformation in the financial sector forces authorities to act as a LLR, which creates a *collective risk-shifting* of private banks that, for instance, engage in investments that create correlated portfolio risks.

A popular way to try to mitigate potential moral hazard problems related to ex-post interventions in periods of financial distress is "*the constructive ambiguity approach*" (Enoch et al. 1997). The key idea is to maintain ambiguity about potential bailout policies in future periods of financial distress. In this way financial intermediaries cannot fully rely on the existence of bailouts should they face distress. Furthermore, constructive ambiguity about the bailout policies can reserve central banks some valuable discretion. The resulting policy uncertainty may in principle have a mitigating effect on excessive risk-taking by financial institutions and incentivize private liquidity provision. Furthermore, it can help to preserve some of the merits of market discipline (Freixas 1999). However, the effectiveness of the constructive ambiguity approach has been questioned in the

36 The practical importance of this positive disciplining effect of short-term funding is, however, a moot point. In particular, when banks have large exposures to tradable securities, the disciplining effect is likely to play a smaller role, with the short-term debt leading to inefficient liquidations (Huang and Ratnovski 2011).

light of the GFC, and we will come back to it when describing the key trade-offs for public liquidity provision in Section 6.4.

When it comes to mitigating potential unintended distortions that give rise to different forms of moral hazard and risk-taking, the calibration of collateral frameworks also plays an important role in curtailing moral hazard if calibrated conservatively or, instead, impair market discipline if applied too freely. This is because financial institutions may be inclined to pledge their lowest quality collateral with the central bank during times of system-wide financial distress, with potential implications for market discipline and for the solvency assessment. During a crisis, an insufficient conditioning of LA on solvency risk can be an obstacle to financial sector deleveraging and the reduction of balance sheet risks (Acharya and Tuckman 2014).

In addition, the collateral frameworks of central banks do not only influence the asset-side maturity decomposition of financial intermediaries, but they can also distort the allocation of credit in the economy at a given maturity. If the funding of certain types of illiquid long-dated assets is favored by central bank collateral frameworks, then this may fuel an over-investment in these long-dated assets by making them more liquid (Nyborg 2015). The generally low haircuts on sovereign debt and on certain assets such as mortgage loans could impede the role of financial intermediaries to engage in maturity transformation by causing an under-investment in certain long-dated private assets such as corporate loans.

As Nyborg (2015) argues, the ECB's full allotment policy for its MROs may serve as an example. While it may be useful for extraordinary LA in the light of stigmatization to extend MROs at a fixed rate with full allotment (see Section 4.1.3), such a policy can give rise to a segmented market where the lowest qualities are exclusively used to borrow from central banks. Hence, a prolonged policy intervention of this type may not only affect the credit allocation, but also give rise to a moral hazard problem through the impairment of market discipline (Acharya et al. 2015). Hereby, also the exposure of banks and central banks to sovereign debt received considerable attention. This is in part due to the European sovereign debt crisis, which erupted in late 2009. From a behavioral viewpoint, the sovereign-banking nexus implies that financial intermediaries can have an incentive to over-expose themselves to domestic sovereign debt, which they can use as collateral to access the central bank facilities for liquidity provision. Such incentives can result from a classic risk-shifting (exposure to joint failure states of sovereigns and intermediaries), regulatory arbitrage, or moral suasion (Acharya and Steffen 2015). However, the ability to pledge sovereign bonds with the central bank at a small haircut is essential for such incentives to play out fully. In effect, small or no haircuts on sovereign debt may not only pose

risks for central bank balance sheets, but also distort credit towards sovereigns and away from investments in the private sector. Hence, central bank liquidity facilities that foresee too small a haircut for sovereign debt may induce financial intermediaries to over-invest in sovereign debt even absent the aforementioned sovereign-banking nexus.

More generally, haircuts and pricing play a key role when it comes to the calibration of collateral frameworks. Conservative haircuts and less favorable pricing make it less attractive to financial institutions to pledge certain types of collateral. Thus, haircuts and pricing are important tools in limiting a potential impairment of private liquidity provision, as well as in dealing with moral hazard.[37] Another tool is to apply constraints that limit the quantity of certain types of collateral that an individual counterparty can pledge with the central bank. Hereby, the distinction between normal and crisis times is important. While a conservative calibration of the collateral framework is appropriate during normal times and during idiosyncratic stress events, a systemic liquidity stress event may require the LLR or MMLR to lend *widely* to financial institutions. To do so, the LLR may attempt to support core collateral values by buying and selling freely at a sufficiently wide, but not too wide, spread around the prices that would prevail in normal times (as opposed to conservative crisis time collateral values). Hereby, the clear aim of a MMLR is to reduce risk premia and improve the funding conditions of financial intermediaries.[38]

As a result, central banks face a difficult balancing act. Achieving all goals at all times is challenging and can involve difficult trade-offs. The design of facilities and the crisis response need to take many factors into account. It is worth noting, however, that perhaps the most important tools to mitigate unintended behavioral implications are outside the tool kit of central bank liquidity provision: the regulatory frameworks for financial markets and financial institutions (e.g. bank capital regulation and liquidity regulation).

6.2 Risks to central bank balance sheets

It is well known that LA bears considerable risks for a LLR. During a financial crisis, the decomposition and size of central bank balance sheets typically undergo

37 See also discussion on the potential moral hazard problem related to the discount window penalty rate in the light of Bagehot's classical LLR doctrine and its modern pendant of a MLLR who provides liquidity at a wide bid-ask spread around the price that would prevail in normal times (Section 2.4).

38 During the episode of quantitative easing after the GFC, some central banks changed the decomposition of their balance sheets towards riskier assets. Such a policy influences both the relative supply and price of safe assets, as well as the central bank's risk exposure (Cecchetti 2009).

drastic changes.[39] LA often entails the extension of loans to the private sector on a large scale. Symptomatically, the resulting drastic changes in balance sheet decomposition can be associated with substantial financial risk for the central bank. We can distinguish between credit risk, interest rate risk and currency risk. Credit risk is associated with any type of LA and is related to the counterparty's creditworthiness and to the quality of the collateral. Interest rate risk arises with the provision of term-liquidity and currency risk arises when either the collateral is denominated in foreign currency or when a central bank conducts foreign currency LA.

In normal times, central banks traditionally only lend against high-quality collateral – predominantly against government bonds. More recently, some central banks have started to offer active lending facilities that accept a wide range of collateral also in normal times. The most prominent example is the aforementioned ILTR facility of the Bank of England (Box 4). In general, lending against a wider range of collateral exposes to more credit risk. This is true for normal times and even more so for crisis times. Hence, the central bank has to strike a difficult balance between providing an effective backstop to the financial system and risk management.

When it comes to risk management, the solvency assessment is a core problem for central banks (as described in Section 4.1.1) and entails a number of challenges and difficult trade-offs. This is true for emergency lending to individual institutions (ELA) and perhaps even more so, when it comes to an extraordinary market-wide liquidity support in a period of financial distress (MMLR). In the former case of ELA, the solvency of the counterparty may be in question and the central bank (potentially together with the financial regulator and the treasury) is willing to accept any type of collateral, including equity in the distressed institution with the resulting exposure to potential losses.[40] In the latter case of market-wide liquidity provision, the MMLR may relax lending terms (e.g. widen the collateral requirements at moderate haircuts) to tackle a scarcity of private sector collateral, as described in the previous sections. Such a relaxation of lending terms might constitute considerable risks for the central bank balance sheet given the potentially large magnitude of interventions.

An additional concern for the central bank's solvency assessment during times of system-wide financial distress is that private banks may be inclined to use their lowest quality collateral for borrowing from central bank facilities, as discussed

39 See Cecchetti (2009) for a detailed description of the evolution of the Fed's balance sheet decomposition during the early stage of the global financial crisis, and Borio and Nelson (2008) for a study on the Euro Area, Japan, the United Kingdom, Canada, Australia and Switzerland.

40 Well documented examples are Kaupthing Bank Sverige AB (the Swedish subsidiary of the Icelandic bank) and Carnegie Investment Bank AB, which both received ELA from the Riksbank in October 2008 (Bryant et al. 2012).

in Section 6.1. The main instrument to deal with credit risk on the central bank balance sheet is the use of sufficiently conservative haircuts that allow for substantial falls in collateral values, but at same time facilitate liquidity provision to the financial sector. In this way central banks can not only attempt to address the unintended behavioral implications discussed previously, but also limit their exposure to counterparty risk.[41]

6.3 The monetary policy dimension

There is a debate about how sharp a line one should (or could) draw between monetary policy and financial stability (e.g., Borio (2014), Billi and Vredin (2014), Stein (2013), Svensson (2016)). This debate is related to the possibility of using micro- and macroprudential tools (and monetary policy) to mitigate credit booms and thereby reduce the probability and intensity of a financial crisis looking ahead. At the same time, the interaction between monetary policy and liquidity policy, which is most relevant during episodes of financial instability, has received relatively less attention. In this section, we discuss potential pitfalls that may arise if the distinction between monetary and liquidity policy becomes blurred during financial crises, or if the objectives of public liquidity provision conflict with the objectives of monetary policy.

The link between monetary and liquidity policy is evident from our discussion in Sections 2.5 and 3.5. While central bank liquidity provision is an important aspect in assuring a well-functioning transmission mechanism of monetary policy in affecting market interest rates and economic activity, the use of extraordinary open market operations in relation to the fulfillment of the central bank's role as a LLR during periods of financial instability may pose challenges. Specifically, a blurring of the distinction between monetary and liquidity policy may arise if extraordinary OMOs are used over a longer time horizon so that regular OMOs used to steer the overnight interest rate become indistinguishable from liquidity support to the wider financial system.

Furthermore, conflicts between monetary policy and liquidity policy objectives may emerge when flexibility on the future policy rate path is desirable from a monetary policy viewpoint, while a commitment to an expansive and cheap overnight liquidity provision is desirable from a financial stability viewpoint. One way to address such conflicts is to introduce longer-term liquidity providing operations with maturities up to several months (see, e.g., the Fed's TAF or the ECB's LTRO) that

41 In this context it is also worth mentioning that central banks may have an informational advantage vis-a-vis the private sector as they can draw from detailed regulatory information when assessing the solvency of their counterparties. This informational advantage further underpins the role of central banks as natural liquidity providers discussed in Section 2.2.

preserve monetary policy flexibility on short-term rates. A different challenge may arise especially for small open economies if expansive liquidity operations cause depreciation pressures on the domestic currency that counteract monetary policy objectives, creating a tension between financial stability and monetary policy.

6.4 Trade-offs going forward

We next highlight some key trade-offs that have been shown to be relevant from the recent GFC experience and are likely to shape the policy discussion going forward.

6.4.1 Constructive ambiguity vs. ex-ante transparency

As mentioned earlier, constructive ambiguity is one way to mitigate potential moral hazard problems related to ex-post interventions in periods of financial distress. A key policy question is whether central banks should be ex-ante transparent about the availability of LA, and if so how much. In practice, there are substantial differences in the transparency of central banks on the availability of contingent (or 'dormant') facilities that could be activated in stress scenarios and, more generally, on the lending conditions for certain contingencies.

One can distinguish between ex-ante transparency about the high-level strategy for LA and the framework for LA. While the aim of the former is to give some high-level guidance to market participants on what to expect from the LLR in certain contingencies, the latter entails the communication of more specific information about the available facilities and the terms and conditions thereof. While the majority of central banks remain rather opaque about contingent facilities, some central banks have introduced explicit *contingent* or *permanent* dedicated facilities for LA with differing degrees of transparency about the lending terms. For instance, the Bank of Canada and the Bank of England have introduced the aforementioned Contingent Term Repo Facility after the GFC. Both central banks provide some high-level guidance regarding the activation and use of the CTRF. An example of a permanent dedicated facility for LA is the Committed Liquidity Facility (CLF) of the Reserve Bank of Australia introduced in 2015. The CLF gives financial intermediaries access to a special lending facility in exchange for an up-front fee. Besides its permanent nature, the CLF differs from the CTRF in that it offers term-liquidity at predetermined prices and quantities to participating counterparties. Thus, it can be said that there is a high degree of transparency about this part of the LA framework.

Contingent facilities may be seen as part of a flexible operating framework to ensure an effective crisis response looking ahead. Besides, the availability of contingent facilities in periods of systemic liquidity stress may improve the

resilience of financial markets and reduce the problem of stigma. This is because financial intermediaries may be more willing to provide private liquidity to one another when they are sure that they can rely on a backstop by the LLR. Hence, transparency and disclosure are not only important when it comes to potential moral hazard problems related to the design of a central bank's lending facilities and the contingency planning for LLR interventions. In fact, it may also have relevant implications when it comes to the provision of an effective backstop to the financial system. However, moral hazard remains a concern and its potential costs have to be limited and balanced against the benefits of ex-ante transparency. Moreover, an advantage of constructive ambiguity about the existence of contingent facilities may be that the policy maker retains a higher degree of flexibility and discretion.

It is useful to distinguish between bailouts of individual institutions that are struggling and systemic liquidity stress events. While it is easier for a LLR to credibly commit not to bail out individual institutions in certain states of the world, it becomes difficult to credibly commit not to bail out private financial institutions in periods when market confidence is impaired. Similarly, it is almost impossible to credibly commit not to bail out systemically important institutions. Hence, there is a serious time-inconsistency problem surrounding the constructing ambiguity approach. Symptomatically, constructive ambiguity went quickly out of fashion during the GFC (Domanski et al. 2014). After the failure of Lehman, the too-big-to-fail problem outweighted potential solvency concerns during liquidity operations. From a theoretical viewpoint, Goodhart and Huang (2005) argue that contagion risk not only affects the LLR policies of a central bank, but also the disclosure policies. Specifically, the LLR faces a trade-off between moral hazard related costs and the contagion risk. The optimal LLR policy of the central bank may be time-varying and non-monotone in the size of a bank.

In sum, the trade-off between the benefits and costs of constructive ambiguity and transparency is multi-dimensional. The multi-dimensionality arises because central banks can choose varying degrees of transparency for different facilities. In practice, the potential benefits and costs of constructive ambiguity-type communication policy crucially depend on the design of facilities and on credibility. If the LLR lacks credibility, it is impossible to solve the moral hazard problem since market participants inevitably form expectations about potential bail outs.[42] As a result, the right balance between the advantages of rule-based and ad-hoc elements of a central bank's framework for LA, as well as the communication thereof remain an important challenge.

42 In fact, not being ex-ante transparent about the strategy for LA may cause market participants to form too favorable expectations about bail outs and, thereby, amplify the moral hazard problem.

6.4.2 Outreach vs. credit risk and market discipline

The overarching goal of central bank liquidity policy to provide a backstop and to reach the market participants in need of liquidity may entail the broadening of the scope of public liquidity provision along several dimensions during an episode of financial instability. All dimensions of broadening have the potential to close certain gaps in existing frameworks for LA as discussed in Section 5. What is important, however, is to balance these advantages against potential pitfalls.

The widening of the access to LA in terms of institutional eligibility and the widening of the range of eligible collateral pose substantial challenges to central bank credit risk management. Central banks usually lend to a limited circle of counterparties that act as intermediaries and redistribute liquidity in the financial market. Lending to a smaller circle of counterparties against highest-quality collateral has the advantage that counterparties and collateral qualities can be monitored more closely. Instead, a widening of the access to LA requires very careful management of the central bank collateral framework, in order to contain the credit risk assumed by the central bank. This problem is compounded when private sector collateral is negatively affected by distressed markets (see Section 4.1.1). Similarly, central bank lending at longer maturities and in foreign currencies during episodes of financial instability involves additional risks for the central bank. The anticipation of a broadening of public liquidity provision along these dimensions in systemic stress events can impair market discipline and create moral hazard problems for the aforementioned reasons. While the potential costs may be reduced by carefully calibrating the collateral frameworks and the pricing of central bank lending facilities, it is important to balance the benefits of widening the access to LA in systemic stress events against the implications for central bank balance sheet risk.

The pricing of central bank lending facilities in itself may, however, give rise to a trade-off for the LLR who needs to balance the advantages of a favorable pricing of the lending facilities, such as a reduction of a problem of stigma and the reduction of market distress, against the potential negative implications related to moral hazard and a distortion of the credit allocation. To this end, a lending facility with ex-ante pricing such as the CLF may be attractive. The CLF can be seen as costly liquidity insurance and was introduced in the light of a shortage of HQLA in Australia that may cause a high liquidity premium.[43] In a 2013 speech, Jeremy Stein entertains the idea that a CLF may also be appealing in an environment without a shortage of HQLA if the pricing of the facility is calibrated in such a way that there is a low usage in normal times and high participation in crisis times,

43 The Basel Committee allows Australian banks to count their costly access to the CLF towards the fulfillment of the regulatory liquidity buffer.

thereby reducing the problem of stigma (Bech and Keister 2013). While one may argue that a CLF does not solve the moral hazard problem, it remains to be said that the up-front fee can be balanced against the LLR's potential costs ex-post.

In sum, central banks face a number of trade-offs related to transparency, the scope of central bank liquidity provision, the collateral frameworks and the pricing of lending facilities. This section sets out a number of pitfalls that need to be balanced against the benefits of certain policies. Furthermore, we offer some indication on how some of the pitfalls may be addressed so as to reduce the costs and unintended implications of central bank LA.

7 Further challenges ahead

Regulatory, structural and technological developments in the financial system create new challenges for central bank liquidity provision. In this section, we try to look ahead and discuss some of these new developments, and the potential challenges they bring along. Some developments pose specific concerns for the Swedish financial system.

7.1 Challenges for liquidity in connection with resolution

The GFC triggered intensive activity among international standard setters to reform the regulatory framework with a view to increase the resilience of the financial system and, in particular, to eliminate the too-big-to-fail dilemma. Besides enhancing, for example, capital and liquidity buffers, considerable efforts have been devoted to achieving effective resolution regimes that would force shareholders and creditors to take a greater responsibility for losses instead of, in effect, making taxpayers foot the bill for bank failures. At the same time, a new resolution regime aims to make it possible to wind down or reconstruct a failing bank in an orderly fashion so that critical functions can be maintained and without causing disruptions to the rest of the financial system.

The primary mechanism that is supposed to accomplish these twin goals is called "bail-in". This is essentially the ability to write-down some of the bank's debt to unprotected creditors and/or convert the holdings of these creditors into equity (after the original equity holdings have been wiped out). This allows, in principle, the bank to be instantly recapitalized whilst authorities are given some time to decide on the further treatment of the failing bank (see Box 6 on a new resolution regime).

While the new resolution framework may, in principle, reduce the risks to taxpayers and mitigate the moral hazard problem by enhancing the enforcement of market discipline by investors, it provides little guidance on the provision of

central bank liquidity in connection to resolution. From the perspective of central banks, the link between LA and the timing of the resolution trigger is delicate with important implications for central bank balance sheet risk management. In addition, LA to an insolvent financial institution undergoing resolution may be subject to strict EU-wide restrictions on State aid[44] and monetary financing.[45]

Moreover, the higher risk of unsecured debt holders to be bailed in is likely to make them less likely to lend to banks in a period of financial distress, thereby creating an amplifying mechanism. Such an amplifying mechanism can also occur when more assets of private banks become encumbered during a period of extraordinary market-wide LA. On a different matter, the resolution frameworks may also increase the tendency to rely on central bank LA from other authorities, simply because central bank LA in principle enables forbearance, such as postponing decisions to trigger resolution, or delaying the practical execution of resolution by responsible authorities.

7.1.1 ELA before resolution

As mentioned, there is a delicate link between LA and the timing of the resolution trigger. Notably, the BRRD does not regulate what happens when a bank to which the central bank has granted ELA (on the presumption that its liquidity needs are merely temporary) is suddenly deemed to be "failing or likely to fail" by the relevant authority and thus passed on to the resolution process. Since it is typical in the nature of emergency situations that ELA will sometimes have to be granted with less than perfect foresight and therefore without knowledge of the true value of pledged collateral, it is would seem important that the status of central bank debt in resolution is clarified. To the extent that the true value of the collateral does not fully cover a central bank credit, there is a distinct possibility that the central bank's remaining claim would be bailed-in at the very moment the bank is placed in resolution. In light of central bank mandates, such an outcome may be problematic for several reasons.

First, it would imply that the central bank takes over a task that is essentially one that belongs to the central government, that is, to deal with insolvent banks. Besides being questionable from a perspective of the monetary financing prohibition, increasing the potential loan loss on the central bank's balance sheet could undermine incentives to extend ELA in future. Second, it would not seem appropriate that public funds, which are essentially meant to salvage the bank

44 The European Union (EU) Article 107 of the Treaty on the Functioning of the European Union defines and sets restrictions on "State aid" measures (or Government subsidies) that confer, through public resources, economic advantages to selected entities, affecting trade between EU Member States.
45 See Article 123 of the Treaty on the Functioning of the European Union.

from temporary liquidity problems, in effect are expended to bail out private creditors.

A state guarantee backing central bank ELA could possibly be instrumental in dealing with the first problem. However, to mitigate the second problem, it would presumably be necessary to also give central bank claims seniority over other claims in the hierarchy of creditor claims. In general, to reduce costs to society, it would also seem important that the decision to trigger resolution is transparent, and that responsible authorities are discouraged from delaying this decision.

7.1.2 ELA in resolution

A bank in resolution may also be in need of funding liquidity in order to pay its debts as they fall due. The liquidity need is primarily governed by the type of actions that the resolution authority intends to take vis-à-vis the distressed bank, for example, what tools it intends to use (see Box 5). In the base case, the bank's liquidity needs will be satisfied by the market, possibly contingent on a guarantee issued by the resolution authority. However, it may take some time before sufficient confidence is restored to once again make market funding accessible to the bank undergoing resolution. Therefore, at least in the initial stages, the public sector might have to supply liquidity. Thus, central bank ELA may also become an option in resolution.

In Sweden, and in other EU countries, it may, however, prove difficult to reconcile the central bank task of providing ELA to failing banks with the prohibition of monetary financing, especially if the company is already placed in resolution. In Swedish law, the insolvency concept is based on forecasts of a company's future solvency. This means that a bridge institution or a company in resolution may be considered solvent if the resolution measures aim to make the company survive and able to honor its obligations.

Certainly, a large, failing bank is likely to be taken care of by the resolution authority in a so-called "open-bank" resolution, which means that the bank will be able to continue to operate as the same legal person as before and would be recapitalized using the bail-in tool. In such open-bank resolutions, the solvency assessment would not be a big concern. However, there may also be instances when the resolution measures are not set on survival of the company's present legal entity, but rather on selling part of the business and then passing on the rest of the company to bankruptcy proceedings. Whether a central bank credit ends up in a legal entity that survives resolution or in a part that is going into bankruptcy may thus have crucial implications for the solvency assessment.

Box 5 – A new resolution regime

FSB and BRRD In November 2011, the Financial Stability Board (FSB) published the document ”Key Attributes of Effective Resolutions Regimes for Financial Institutions” (Henceforth: “Key Attributes”). The document contains recommendations to jurisdictions with global systemically important financial institutions (G-SIFIs). These recommendations were used as a basis for, *inter alia*, a legislative proposal put forward by the EU Commission, which, after intensive negotiations, resulted in the European Parliament’s and the Council’s Bank Recovery and Resolution Directive (BRRD) being adopted by the European Parliament and the Council of Ministers on 15 April 2014 and 6 May 2014 respectively. The BRRD entered into force on 1 January 2015.

While the FSB Key Attributes pertain to the rather exclusive set of G-SIFIs, the BRRD provides a framework pertaining to basically all credit institutions and investment firms in the EU. The purpose of the BRRD is not only to provide effective tools for reconstructing or winding down failing institutions, but also to avoid individual institutions developing problems that could necessitate resolution. BRRD therefore contains provisions not only about resolution, but also about preparations for this procedure and precautionary supervisory measures.

Provisions on crisis prevention The provisions on crisis prevention include both preparations for resolution and purely supervisory measures. There will be new requirements for the establishment of recovery plans and resolution plans, as well as the possibility of requiring institutions to remove obstacles to an effective resolution. Early intervention, including the appointment of a temporary administrator, is also part of the crisis prevention framework. Early intervention gives the supervisory authorities the opportunity to prevent a deterioration of the institution’s financial position to the point where resolution is the only alternative. The crisis prevention work will also include the option of writing down and converting debts that can be included in the capital base and requiring institutions to have sufficient liabilities suitable for bail-in.

Resolution The principal aim of resolution is to reconstruct or wind down financial institutions that fail without causing serious disruptions to critical services. Resolution can thus be seen as an alternative to bankruptcy or liquidation. The BRRD stipulates that resolution authorities should be responsible for managing the procedure and ensure that the purpose of the procedure, which is primarily to address serious disruptions in the financial system, is achieved in

the best possible way. In Sweden, the National Debt Office officially became the designated resolution authority on 1 February 2016.

When an institution is placed under resolution, control of the institution is transferred to the resolution authority. The resolution decision also entails a number of other legal consequences such as prohibiting the seizure of assets. The resolution authority also has the right to stop the fulfillment of contracts or require fulfillment. One of the main reasons for placing a failing institution under resolution is that the continuance of its activities is essential to avoid serious disruptions in the financial system. Therefore, either the activity has to be transferred to a financially sound party or the company has to be reconstructed. There are four resolution tools for this purpose:

1. **The sale-of-business tool**, which allows the resolution authority to sell assets, liabilities and shares in an institution under resolution to a private purchaser.
2. **The bridge institution tool**, which allows the resolution authority to transfer assets, liabilities or shares from the institution under resolution to a temporary bridge institution controlled by the resolution authority.
3. **The asset separation tool**, which allows the resolution authority to transfer assets to a specially established asset management company for gradual sale in the market. This tool may only be applied in conjunction with another resolution tool.
4. **The bail-in tool**, which allows the resolution authority to write down the liabilities of an institution under resolution and/or convert them to shareholdings.

The resolution authority's use of resolution tools is based on a number of powers enabling it to intervene in an institution under resolution and take action against its owners and creditors. In certain circumstances, these powers may also be used independently, without associating them with a particular tool. Before the resolution authority uses any tool or power that may lead to any creditor losses, the resolution authority is to take measures forcing owners to bear losses first and fully. This is to maintain the order of precedence that would have applied if the institution had instead been forced into bankruptcy.

Resolution involves intervention in individuals' rights. For this reason, there are a number of provisions that limit and impose requirements on the resolution procedure in order to preserve a fundamental right to property for different stakeholders. One important provision of this kind is the requirement for an assessment of whether any owner's or creditor's financial outcome is worse than in a normal insolvency or liquidation procedure. If so, the affected party has a right to compensation.

7.2 Cross-border challenges

The increased cross-border activities are not only a concern because they constitute a channel for international liquidity spillovers,[46] but they are also relevant when it comes to liquidity assistance to subsidiaries of foreign banks and to foreign CCPs that fulfill an important role for the functioning of the payments system. The international dimension raises both questions about the importance of international cooperation in LA and about the burden-sharing in case of potential losses from public liquidity provision that accrue in different jurisdictions. These issues are particularly relevant for Sweden with its relatively large financial sector (see Figure 1 in Section 2) that is characterized by a high degree of internationalization and connectedness, as can be seen in Box 6.

The high degree of cross-border integration of the banks in the Nordic-Baltic countries requires close cooperation among authorities in the region. For a long time, there have been supervisory colleges for the four major Swedish banks. Moreover, since 2010 there is a Memorandum of Understanding (MoU) in place between relevant authorities – basically central banks, supervisory authorities and finance ministries – regarding cooperation in relation to crisis management. However the new resolution framework has instigated a need to review and further develop the arrangements for cross-border cooperation. For example, the FSB Key Attributes recommend the formation of firm-specific Crisis Management Groups (CMGs) and the attainment of firm-specific cross-border cooperation agreements (COAGs) for G-SIFIs. In 2012, a Nordea-specific CMG was established. The EU BRRD takes the cooperation requirements even a step further, providing a broad framework for cross-border cooperation on issues related to resolution. Recently, the Swedish National Debt Office, in its capacity as designated resolution authority in Sweden and consolidating resolution authority, formed, in accordance with BRRD, resolution colleges for the four major Swedish banking groups.

The cross-border cooperation challenge is of course also highly relevant for central banks. Cross-border banking groups will have obligations and thus liquidity needs in different currencies. Liquidity shortages may occur that could require close cooperation and coordination among central banks. The MoU between Nordic central banks that has existed since 2003 is currently being reviewed.

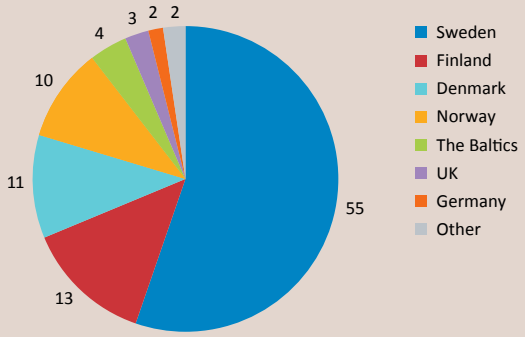
46 See IMF Spillover Report (2014,2015), and Bruno and Shin (2015a,2015b).

Box 6 – Cross-border activities of Swedish banking groups

The four major Swedish banking groups (Handelsbanken, Nordea, SEB, and Swedbank) conduct a significant part of their operations outside Sweden – primarily in other Nordic countries and in the Baltics. Around 47 per cent of the four major banking groups' lending to the public is to customers abroad. Figure B6.1 below depicts the geographic distribution of the Swedish banking groups' lending to the public.

Among the Swedish banking groups, the Nordea Group is the largest one. Nordea, being on FSB's list of G-SIFIs, has the largest proportion of lending to borrowers outside Sweden among the Swedish banks. About 76 per cent of Nordea's lending is to the general public abroad, and only less than a quarter to the Swedish public. The other three major banking groups have an average of one quarter of their operations abroad.

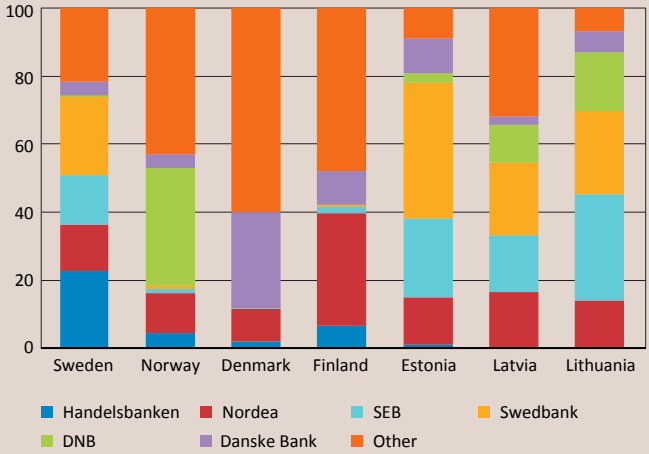
Figure B6.1. Total lending to the public by the four major Swedish banking groups, geographic distribution (percent), March 2016



Source: The Riksbank

The significant presence of Swedish banks in other Nordic and Baltic countries make them effectively systemically important in these countries. Figure B6.2 below depicts the four major banking groups' market shares in the Nordic and Baltic countries. Notably, also Danish bank *Danske Bank* and Norwegian bank *DNB* (shaded areas) have significant cross-border activities in the Nordic-Baltic region besides the four major Swedish banks.

Figure B6.2. Market shares measured by total lending to the public
Percent



Notes. Sweden: Nov 2015; Source: Statistics Sweden
Norway: Q4 2014; Source: Norges Bank
Denmark: Q3 2015; Source: Danmarks Nationalbank
Finland: Q3 2015; Source: Bank of Finland
Estonia: Q4 2014; Source: Estonian Banking Association
Latvia: Q3 2015; Source: Association of Latvian Commercial Banks
Lithuania: Q3 2015; Sources: Central Bank of the Republic of Lithuania; Association of Lithuanian Banks

A particular circumstance that speaks in favor of enhancing cooperation among central banks is the fact that the Nordea Group has initiated plans to make changes to the bank's corporate structure. The plan is to move from the present group structure, where foreign operations essentially are carried out by separate legal entities incorporated the other Nordic countries acting as foreign subsidiaries to the Swedish parent bank, to (largely) a branch structure, where foreign operations are carried out by branches of a single, Swedish entity. Such a branch structure increases the Swedish overall potential liability in case Nordea finds itself in dire straits financially. The presumption that the Riksbank will be primarily responsible for potential LA will be stronger, which emphasizes the need to ensure that liquidity in relevant currencies will be available. In a situation where foreign exchange markets are still functioning well, swapping SEK into the desired currencies will not be a concern. However, in a severe crisis scenario where foreign exchange markets are adversely affected, this may prove challenging. Some precautionary measures, such as having swap agreements drawn up between the Nordic central banks, or reinforcing or rebalancing the Riksbank's currency reserve with the relevant currencies, may need to be considered in some circumstances (Sveriges Riksbank 2016).

7.3 Challenges in relation to liquididty to financial market infrastructures

One implication of the changed regulatory framework for the financial sector is the increased necessity to carry out derivatives trades through a central counterparty clearing house (CCP) rather than "over-the-counter" (OTC). This, in turn, has increased the systemic importance of the CCPs providing this service. The extent to which existing burden-sharing arrangements and other arrangements among CCP members/owners should be supplemented with regulatory requirements and, in particular, new central bank liquidity arrangements, is something that is currently being discussed among regulators and central banks. For instance, the Bank of England has already made some arrangements explicitly available for CCPs (see Box 4 on Bank of England's Sterling Monetary Framework in Section 5). As is the case with liquidity facilities aimed at banks, arrangements aimed at market infrastructures and other institutions also entail difficult trade-offs that need careful consideration.

7.4 Challenges due to advances in financial technology

Technological innovation is an (increasingly) important factor behind structural changes in the financial sector. In the payments services area, the technology

for mobile payments has become an important competitor to other payment methods. As a result of the development of blockchain technology, digital currencies, such as bitcoin, have evolved as an alternative to currencies issued by central banks,[47] in particular in cross-border transactions.[48] Traditional securities trading has increasingly been challenged by automated trading processes, such as high-frequency trading. In asset management, the use of automated algorithms is gaining ground at the expense of traditional portfolio management methods. In credit services, crowd-funding and peer-to-peer lending have gradually become an alternative to bank lending.

Naturally, advances in financial technology (FinTech) bring about new opportunities, and in many ways they are likely to be welfare-enhancing by providing more efficient business models and more diversity among financial service providers and products. However, at the same time, FinTech innovations can introduce new risks for individual agents as well as for the financial system as a whole. So far, the risk debate has mostly focused on integrity risks, such as concerns over cyber security[49] and money laundering (bitcoins), and to some extent operational risks.

Not least the emergence of digital currencies has given rise to a whole host of existential questions for central banks, concerning their role as guardians of the payments system and their national currency, and as makers of monetary policy. Several central banks, such as the Bank of Canada, the Bank of England and the Fed are currently experimenting with blockchain technology to implement digital versions of their national currencies.

More recently, FinTech developments have also sparked discussions on potential financial stability implications. An example is the rapidly growing market for crowd-lending and peer-to-peer (P2P) loans.[50] In this market, investors have to trust the information and credit ratings provided by the P2P platforms. This trust is particularly relevant since a large market segment of P2P lending is currently uncollateralized consumer credit. It has been shown that investors' perceptions about the underlying credit risk can vary a lot in the crowd-lending market (Bertsch et al. 2016), which can make it prone to confidence shocks after adverse

47 See, e.g., Boel (2016).

48 Blockchain is basically a distributed ledger in which transactions performed around the same point in time are stored as blocks on computers connected to the network. The ledger grows as the chain of blocks increases in size. Each new block of transactions has to be verified by the network before it can be added to the chain. This means that each computer connected to the network has full information about the transactions in the network.

49 In 2016, Bangladesh Bank was the victim of a cybercrime that could have resulted in the loss of nearly USD 1bn (see, for instance, Mallet and Chilkoti 2016).

50 Peer-to-peer (P2P) lending is the practice of lending money to individuals or businesses through online services that match lenders directly with borrowers.

news.[51] Therefore, a loss in confidence may lead to a sudden dry-up of credit origination and destabilize the market for securitized P2P loans. Provided that the crowd-lending market continues to gain importance, such a loss in confidence in P2P lending can have relevant negative spill-overs to the banking sector and disrupt the supply of credit to the economy. From a central bank perspective, LA in support of the market for securitized P2P loans may become a potential policy response to such a scenario.

On top of this, there are reasons to keep a keen eye on the potential effects of some FinTech advances on procyclicality, concentration risks, and on banks' liquidity risks resulting from increased automation. Lately there have been discussions about the potential consequences of so-called *portal aggregators* that are able to automate the allocation of deposits between different banks. In theory, such applications could give rise to self-enhancing patterns of deposit re-allocation. More precisely, if deposit allocation algorithms move enough deposits from one bank to another, it might trigger more algorithms to do the same. In other words, we may have a systemic liquidity crisis on our hands more quickly than we previously could imagine.[52] According to the traditional view, liquidity provision by the central bank would play an important role for restoring market confidence in times of liquidity stress. When a bank run is fueled by automatic algorithms rather than by the sentiments of individual depositors and investors, the central bank's role as provider of LA may need to adapt. After all, what does an algorithm care about confidence?

8 Conclusions

This article attempts to offer a review that could help enhance our understanding of the role of central banks as providers of public liquidity. We discuss various challenges for the effectiveness of central bank lending facilities against the backdrop of the global financial crisis of 2007-2009. These challenges help to identify potential gaps in existing mechanisms and frameworks governing liquidity assistance. Moreover, we investigate how the available liquidity policy tool kit can be used to deal with the challenges. Thereby, we also highlight modifications to existing central bank facilities. Based on the empirical and theoretical literature, we point at trade-offs faced by policy makers and describe potential pitfalls, such as unintended implications for the behavior of financial market participants that may arise from the availability of certain central bank lending facilities. Lastly, we

51 A scandal at LendingClub (the largest U.S. P2P platform for consumer credit) in May 2016 illustrates this (see, for instance, Corkery 2016).

52 A similar phenomenon has been pointed out in the case of automated stock market trading as one of the main reasons behind the 2010 Flash Crash (De Nederlandsche Bank 2015).

attempt to look ahead and outline some specific challenges posed by more recent structural, regulatory, and technological developments in the financial system.

Going forward, the right balance between the advantages of rule-based and ad-hoc elements of central bank frameworks for LA, as well as the communication thereof remain an important challenge. Similarly, the calibration of the collateral frameworks and the pricing of facilities pose important trade-offs. Measures to reach market participants in need of liquidity and to deal with the problem of stigma have to be balanced against potential pitfalls.

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Appendix

Table A.1. Definition of key terms

Term	Definition
central bank liquidity	central bank money or securities that serve as collateral in money markets
central bank currency swap	a foreign exchange derivative that is used by central banks to provide liquidity in their own currency to one another
central bank money	financial institutions' deposits at the central bank (also known as reserves or settlement balances)
Emergency Liquidity Assistance (ELA)	liquidity provision to an individual financial institution that is illiquid and lacks sufficient eligible quality collateral
funding liquidity	captures the ease and cost at which financial institutions raise cash to make their immediate payments, either by borrowing in the markets or by selling assets, which depends on the sensitivity of margins and on collateral valuations
High-Quality Liquid Assets (HQLA)	HQLA comprise cash; central bank money; marketable securities by sovereigns, central banks, non-central government public sector entities, the Bank for International Settlements, the International Monetary Fund, the European Commission, or multilateral developments banks; government or central bank debt issued in domestic currencies
LA to market	supporting core collateral values of financial institutions by means of an outright purchase of assets and REPOs
liquidity	captures the ease of transferring future income from long-dated assets into current income
Liquidity Assistance (LA)	supply of liquidity to the private sector with the objective to help its counterparties overcome unusually severe liquidity shortages or to improve the liquidity of dysfunctional markets
Liquidity Coverage Ratio (LCR)	the stock of unencumbered HQLA divided by the projected total net cash outflows over the next 30 calendar days has to exceed 100 percent
liquidity premium	forward rate minus expected future short-term interest rates
liquidity risk	captures the financial risk stemming from the difficulty of selling an asset quickly without affecting the price
LLR and MLLR	captures central bank LA to financial institutions in reaction to an abnormal increase in liquidity demand that is not met by private liquidity provision
market liquidity	captures the ability to execute large security transaction rapidly with a limited impact on market prices

Term	Definition
MLLR	captures central bank LA to the market
monetary policy transmission	process through which monetary policy decisions transmit to the economy and the price level
Net Stable Funding Ratio (NSFR)	the available amount of stable funding divided by the required amount of stable funding has to exceed 100 percent
private liquidity provision	private financial institutions providing liquidity to one another
public liquidity provision	liquidity provided by the central bank or other public entities like the deposit insurance fund or the central government
runnable liabilities	short-term liabilities without insurance or backing from the government that are considered to be prone to withdrawal or roll-over risk
technological liquidity	captures the degree of reversibility of physical investments

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