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# Memorandum 4 - Mortgage prepayment decisions of households*

## Summary

The purpose of this memorandum is to investigate whether there are any incentives for private households to refrain from prepaying their mortgages. Based on actual interest rates and yields over the past 16 years, our analysis shows that it is probably more advantageous for households to save by investing in financial assets such as equity and fixed-income funds than to prepay mortgages. However, this conclusion is sensitive to our assumptions concerning the households' expectations regarding residential mortgage rates. The low volatility in the property market since the mid-1990s could also lead to the risk of sharp declines in the value of housing being perceived as low by households, which probably reduces the households' incentives to reduce high loan-to-value ratios by means of mortgage prepayment. Finally, there are plenty of indications to suggest that a high degree of saving for retirement through collective pension systems, combined with beneficial taxation of private retirement savings, is reducing the households' incentives to prepay mortgages.

## Introduction

In order to analyse the households' mortgage prepayment decisions and other financial decisions, fundamental insight into the financial position of private households is required. A household's balance sheet comprises a number of items. On the asset side, we have the home as well as the human capital, e.g. the value of future labour income which, especially for younger households, is a major asset item. On the liability side, we have residential mortgages and other types of loans such as student loans and consumer loans.

There is also a distinct correlation between the household's balance sheet and its recurring incomes and expenditure. What is known as the life-cycle model assumes that households prefer to even out consumption over their life cycles. Since incomes at the beginning of people's working lives are relatively low, there is a need to

* A large debt of thanks to Louise Oscarius for her initial analysis of the mortgage prepayment decisions of households and to Per Sidén for his valuable technical assistance.

borrow money for consumption, while later in life, when incomes rise, they can repay their debts. During the occupationally active years, it is also necessary to accumulate savings to secure the households' incomes following retirement. In reality, however, the households are faced with various types of credit restrictions, which inhibit their ability to borrow against future labour income for consumption today. There is also a need for contingency savings among households to be able to offset the financial consequences of, inter alia, unemployment or protracted illness.

Accordingly, the size and appearance of an individual household's balance sheet are determined by a number of factors. Important aspects include the household's need to consume housing services, which determine the value of how expensive a home the household wants to buy, the household's wealth, expectations of the yields and risk on assets, how risky the labour income is and the household's current position in the life cycle. The way the balance sheet looks at a specific time also depends on historical outcomes, such as the realised yields on equity and the property markets.[1]

Empirical research into the financial decisions of households has long been limited due to inadequate access to high-quality microeconomic data. However, such microeconomic data at a household level has become available for research purposes during recent years, particularly from the Nordic countries, and we have learnt increasingly about the households' financial decisions.[2] Despite this, many questions remain, such as about the factors that determine the households' mortgage prepayment decisions.

In this memorandum, three reasons that households may be assumed to have for prepaying mortgage loans are studied. The first reason is a general savings requirement. In Sweden, savings are relatively high at the same time as loan-to-value ratios for housing are generally high and the mortgage prepayment rate is low. Our analysis provides an explanation of why households may find it optimal to save in financial assets at the same time as their rate of mortgage prepayment is low. Another reason for households to prepay mortgages is to be found in retirement savings. We analyse whether the high level of savings in collective pension schemes in Sweden could be of significance to the households' choice of loan-to-value ratio for their home. A related question is whether it is more advantageous to save privately for retirement through special retirement savings schemes rather than to prepay mortgages. A third reason for households to prepay mortgages is if the households regard the probability of major negative shocks, such as a significant decline in housing prices, as not being insignificant. This is because such a decline could potentially lead to high costs, resulting in negative equity in the home (e.g. when the value of the home declines to less than the mortgage loan) or in sharply reduced net worth. These so-called lock-in effects make it difficult, for example, to relocate in connection with unemployment.

We have arrived at the conclusion that when the analysis is based on data concerning yields on real and financial assets from 1997 to 2012, there appear to be few incentives for the households to prepay mortgages. A portfolio-selection analysis shows that for most households, it is probably more advantageous to save by investing in financial assets such as equity and fixed-income funds than to save by prepaying mortgages. This behaviour is also in the interest of banks, because fund management generates major gains. The low volatility of the property market during this period also leads to a risk that a sharp fall in the value of homes and thus in the

[1] Research based on Swedish data shows that households are very slow in adapting the composition of their financial portfolio (see Calvet, Campbell and Sodini, 2009).
[2] As a result of the abolition of wealth tax in 2007, data in Sweden on the wealth of individuals is only available between 1999 and 2007.

- households' net worth may be regarded as low by households, even those with considerable exposure to the housing market and high loan-to-value ratios. We discuss the consequences of incorrect expectations on the part of households.

Finally, there are many indications suggesting that high retirement savings through collective pension systems reduce the households' incentives to prepay mortgages. With great probability, the design of the Swedish tax system also leads to it being more advantageous to save for retirement through deductible private retirement savings schemes than to prepay residential mortgages.

## What incentives do households have to save by prepaying mortgage loans? – A portfolio-selection analysis

### Introduction and summary of results

The asset side of the households' balance sheet, especially in younger age groups, is dominated by the ownership of a house or tenant-owned apartment. This is because housing is both a consumer good and an investment item. At the beginning of adulthood, net worth (excluding human capital) is usually low. Accordingly, the value of home ownership in relation to net worth tends to be high in such age groups and then declines as age increases.

Loans must therefore be raised to cover the portion of the purchase of the house or the tenant-owned apartment that cannot be covered by the purchaser's own net worth. The household could, however, choose to mortgage the home to an extent that exceeds what is absolutely necessary (although always under the maximum permissible loan-to-value ratio) and invest the surplus amount in various financial assets. For example, if the householder purchases a home for SEK 1 million and has SEK 400,000 in financial assets, the householder would have to borrow at least SEK 600,000. However, the household may choose to loan more, for example SEK 850,000, and keep the remaining SEK 250,000 for investment in financial assets. If the householder subsequently wishes to increase his/her savings, he/she is faced with the choice of either reducing the mortgage through mortgage prepayment or increasing the savings in financial assets.

The household's choice of the loan-to-value ratio for the house or the tenant-owned apartment is determined by a number of factors. In the following analysis, we focus on the choice between prepaying the mortgage and saving in financial assets. This choice should mainly be based on the anticipated yield and interest rate, and on the risk associated with these factors.[3] In order to estimate the households' optimum choice of portfolio, we use a model in which the household weighs the increase in the anticipated yield against increased variance in the yield, whereby the households with greater risk aversion attach greater importance to the latter factor. Since the yields on the various assets are not perfectly correlated, it is generally considered optimal to invest in a well-diversified portfolio comprising both real and financial assets. For the estimations made in the model, we have used the actual yields on real and financial assets during the period 1997-2012.

The results show that for virtually all of the households, it would probably have been optimal to mortgage their home up to the maximum amount (up to the mortgage ceiling) and then to invest the remaining portion of the wealth in equity funds or in long-term fixed-income funds, whereby the portion invested in equity funds is

[3] However, the household should also take into account other factors, such as the need of liquidity, the risk associated with labour income and tax effects, in their choice of portfolio.

reduced in line with the household's risk aversion and with the value of the home in relation to net worth. These results are a consequence of both low and stable mortgage rates and the high average yields on real and financial assets during the period 1997-2012. The volatility of the yields in the bond and housing markets was also very low during this period. In such an environment, the households' incentives to prepay portions of their residential mortgages are slim.

Households probably base their opinions of future interest rates, yields and volatilities on historical data. Viewed in a longer-term perspective, however, we have recently experienced a special period in this respect. Future interest rates and yields could very well deviate from the average values during 1997-2012. For this reason, we are concluding this section with a sensitivity analysis, which shows that the households' choice of an optimal loan-to-value ratio is highly sensitive to changes in anticipated mortgage rates. An increase in the anticipated real variable mortgage rate by, for example, one percentage point (after tax deductions) compared with the average during 1997-2012 significantly reduces the households' willingness to mortgage their home.

### Historical yields and interest rates

The yield on real and financial assets varies over time. Table 1 shows the average annual nominal yield and the volatility of the yields on short fixed-income funds (known as money market funds), long fixed-income funds, equity funds, the households' actual variable mortgage rates (3-month) and the property price index (single-family homes) during the period 1997-2012. Fund yields are based on Morningstar's published fund index (available since 1997). The property price index and data concerning the households' actual mortgage rates have been compiled by Statistics Sweden. Annual nominal yields are reported in Table A1 in the appendix.

**Table 1. Nominal yields on real and financial assets during 1997-2012**

| | Money market | Fixed-income funds | Equity funds | Mortgages | Property index |
|---|---|---|---|---|---|
| Average value | 2.8% | 5.0% | 8.2% | 4.1% | 6.9% |
| Standard deviation | 1.1% | 3.1% | 24.6% | 1.2% | 3.9% |
| | | | | | |
| Correlation matrix | | | | | |
| Money market | 100% | 55% | -48% | 95% | 10% |
| Fixed-income funds | | 100% | -58% | 48% | -24% |
| Equity funds | | | 100% | -46% | 21% |
| Mortgages | | | | 100% | 11% |
| Property index | | | | | 100% |

The table shows that equity funds generated the highest average annual yield of 8.2% during this period. However, the volatility of the yield was also highest for equity funds, more precisely 24.6% measured as the standard deviation. The yield on long and short fixed-income funds (money market funds) was 5% and 2.8%, respectively, subject to a standard deviation of 3.1 and 1.1%, respectively. The

average variable mortgage rate was 4.1%. The volatility of the variable mortgage rate was also low; the standard deviation was only 1.2%.

As expected, single-family properties were an attractive asset during this period in Sweden, with an average yield of 6.9%, at the same time as the standard deviation of the yield on the property price index was only 3.9%.[4] However, the property price index tends to underestimate the total volatility of the yield for privately-owned single-family properties since it also includes an idiosyncratic risk factor (for a discussion of this, refer to Englund et al. (2002) or Flavin and Yamashita (2002)). Based on calculations with Swedish data of Englund et al, we assume that the variance in the idiosyncratic risk factor is comparable in size with the variance in the yield on the property price index.[5] This assumption results in a total standard deviation for the yield on a privately-owned single-family property of an estimated 5.5%.

The correlation between the nominal yields on equity funds and long fixed-income funds is negative (-0.58). However, there is a slightly positive correlation between the yields on the property price index and on equity funds (0.21). The correlation between the yield on the property price index and the variable mortgage rate is close to zero (0.11), while the correlation between the property price index and long fixed-income funds is negative (-0.24). As expected, the yield on money market funds and the variable mortgage rate is very strongly correlated, with a correlation coefficient of 0.95.

Corresponding yields, after inflation and tax, are reported in Table 2.[6] Annual real yields are reported in Table A2 in the appendix. This shows that the average real yield on single-family homes during this period was 4.1% after tax. For equity funds, the corresponding figure was 4.5%. Long fixed-income funds have generated a real yield of just over 2% and money market funds of around 0.5%. The variable mortgage rate after interest-rate deductions and inflation was an average of 1.6%. In general, the correlations between the real yields are positive. Only the correlation between the real yield on equity funds and long fixed-income funds is negative (-0.16).

[4] Unfortunately, there is no price index for tenant-owned apartments during this period. We assume in the analysis that the prices of tenant-owned apartments have trended in line with the prices of single-family properties.

[5] The idiosyncratic risk factor is assumed to have an expected value of zero and to be uncorrelated with the yield on other assets.

[6] In this case, we use a rate of 30% for tax on financial assets, a 30% tax-deduction right for interest expenses and a 22% capital gains tax on single-family houses and tenant-owned apartments. However, effective tax rates for the various assets depend on the household's investment horizon.

**Table 2. Yields after inflation and tax on real and financial assets during 1997-2012**

| | Money market | Fixed-income funds | Equity funds | Mortgages | Property index |
|---|---|---|---|---|---|
| Average value | 0.6% | 2.2% | 4.5% | 1.6% | 4.1% |
| Standard deviation | 1.1% | 2.3% | 17.8% | 1.1% | 3.4% |
| | | | | | |
| Correlation matrix | | | | | |
| Money market | 100% | 62% | 42% | 97% | 48% |
| Fixed-income funds | | 100% | -16% | 59% | 2% |
| Equity funds | | | 100% | 40% | 43% |
| Mortgages | | | | 100% | 48% |
| Property index | | | | | 100% |

The conclusion of this analysis is that the average yields on single-family properties and equity funds in particular, but also on long fixed-income funds, were high during the period 1997-2012, at the same time as variable mortgage rates were low and stable. The volatility of the property price index was also very low during this period. In the next section, these interest rates and yields are used as a point of departure for estimating the households' optimal choice of portfolio.

## Model of optimal choice of portfolio

To estimate the households' optimal choice of portfolio, a portfolio-selection model resembling that of Flavin and Yamashita (2002) may be used. In their model, it is assumed that the home is both a consumable and an investment good. The consumption requirement of housing services is considered to be exogenous (at least in the short term) and may thus be viewed as a restriction in respect of the optimal portfolio selection. More precisely, it is assumed that $h$, e.g. the value of the home in relation to the household's net worth is governed by the household's need to consume housing services. Moreover, other assets, such as pension assets and human capital, are disregarded.

In addition to the home, it is assumed that the household is able to invest in short and long fixed-income funds as well as in equity funds. Furthermore, the household is only able to borrow by using the home as collateral for a variable-interest mortgage. The mortgage loan may not exceed 85% of the value of the home (which sets a ceiling of 6.67 for the initial $h$ in the model).[7] The risk aversion varies among the population, whereby the more risk-averse households demand a higher anticipated yield in order to accept increased risk i.e. increased volatility in the yield.

Given these prerequisites, the household chooses how it is to allocate the investments in the financial portfolio and how much that is to be borrowed using the home as collateral. The higher the $h$, e.g. the higher the value of the home in relation to the household's net worth, the more the household is forced to mortgage the

[7] An $h$ that is equal to 6.67 means that the household mortgages its home up to 85% and uses all of its assets to cover the down payment of 15%.

home, if all other factors remain equal. It is not until *h* is lower or equal to one that the household is able to completely refrain from mortgaging the home.

It is assumed that the households optimise their choice of portfolio given *h*, their risk aversion, the anticipated yield and interest rate, as well as the variance and covariance matrix in a traditional "*mean-variance*" model by maximising

$$\left\{(anticipated\ yield) - \frac{A}{2}(variance)\right\}$$

in which the *anticipated yield* is the anticipated yield on the home and the financial portfolio (including the mortgage loan), *A* is the household's risk aversion and *variance* is the variance in the yield on the home and the financial portfolio. In other words, the household weighs the increased anticipated yield against the increased risk (variance) in the yield, whereby more risk-averse households attach greater importance to the latter factor.

**Empirical results**

The results of the households' optimal choice of portfolio are reported in Table 3, given the real interest rates and yields after tax that applied during 1997-2012 (see Table 2).[8] The loan-to-value ratio, e.g. how large a portion of the value of the home that should optimally be mortgaged (subject to the ceiling of 85%), and how large a portion of the financial assets that is invested in money market funds, long fixed-income funds and equity funds for various values of *h* (the value of the home in relation to the household's net worth) and the household's risk aversion, *A,* are reported in the table.

[8] The results of a robustness test in which the nominal yield is used are presented in Table A3 in the appendix.

**Table 3. Optimal choice of portfolio given real yields during 1997-2012**

| | | $A = 1$ | $A = 2$ | $A = 4$ | $A = 8$ | $A = 10$ |
|---|---|---|---|---|---|---|
| $h = 0.5$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 24% | 62% | 81% | 90% | 92% |
| | Equity funds | 76% | 38% | 19% | 10% | 8% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 1$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 21% | 62% | 83% | 93% | 95% |
| | Equity funds | 79% | 38% | 17% | 7% | 5% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 2$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 14% | 64% | 89% | 100% | 100% |
| | Equity funds | 86% | 36% | 11% | 0% | 0% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 4$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 0% | 70% | 100% | 100% | 100% |
| | Equity funds | 100% | 30% | 0% | 0% | 0% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 6.67$ | Money market | * | * | * | * | * |
| | Fixed-income funds | * | * | * | * | * |
| | Equity funds | * | * | * | * | * |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |

If the household has a high value for $h$, e.g. if the value of the home is high in relation to net worth, the household is forced to at least partly mortgage the house or the tenant-owned apartment to enable the financing. However, the household may choose to take on a mortgage that exceeds this level in order to increase the amount that can be invested in financial assets. The results in Table 3 show that for all values of $h$ and regardless of risk aversion, it is optimal for the household to mortgage its home to the maximum extent, according to the model. We thus note that in all cases, a mortgage ceiling of 85% has a restrictive effect, since even risk-averse households find it optimal to borrow 85% or more of the value of the home.[9]

Given $h = 6.67$, the household has exactly enough resources to borrow the maximum permissible 85% of the value of the home and finance the remaining 15% of the home using its own net worth. Accordingly, no funds are invested in financial assets. Given lower values for $h$, however, the household is able to invest in financial assets. Given $h = 4$ and low risk aversion ($A = 2$), the household should invest 30% of the financial assets in equity funds and remaining portion in long fixed-income funds. If instead the risk aversion is high ($A = 10$), the entire financial asset portfolio should be invested in long fixed-income funds and nothing in equity funds. The results generally show that when risk aversion increases, given a certain value for $h$, an

[9] These results vary from those of Flavin and Yamashita (2002). They found, using US data, that the optimal choice of households with high risk aversion and lower values for $h$ was a lower loan-to-value ratio than the maximum permissible level. The main reason for this was higher volatility in short and long interest rates.

- increasing portion of the financial assets should be invested in long fixed-income funds rather than in equity funds. However, investing in money market funds is never optimal.

Given lower values for *h,* the household should invest an increasing portion of the financial assets in equity funds rather than in long fixed-income funds assuming a certain risk aversion. If $h = 0.5$, the households with low risk aversion ($A = 2$) should invest slightly more than 40% in equity funds and the remaining portion in long fixed-income funds.

The conclusion of the above analysis is that, according to the model, the private household optimises its choice of portfolio by mortgaging its home to a maximum extent and investing the financial wealth in equity funds and long fixed-income funds. The portion of the financial assets that should be invested in equity funds generally declines with the value of *h* and the household's risk aversion. These results are based on the fact that during the period 1997-2012 it was extremely advantageous to utilise the low and stable mortgage rates in order to take on a maximum mortgage in the short term and invest in financial assets such as long fixed-income funds and equity funds. In such an environment, the households' incentives to prepay their residential mortgages are small.

The model is, of course, a simplification of the households' portfolio selection. In reality, households have many intentions to consider when taking their financial decisions other than solely optimising anticipated yield and risk according to the model described above. However, it provides an indication of the households' optimal portfolio selection, even if certain important aspects have been excluded. For example, human capital, e.g. the value of future labour income, is not covered by the model. The model also assumes that no transaction costs arise for buying and selling financial assets. In reality, households require a liquidity buffer in the form of cash and holdings in transaction accounts to be able to cover both ongoing and unforeseen expenditure.

Both private financial costs and socioeconomic costs may also arise if the mortgage exceeds the value of the home or if the household does not have sufficient resources to finance a new home. The household may also base its expectations concerning future interest rates, yields and risks on incorrect grounds. These factors and others are addressed below.

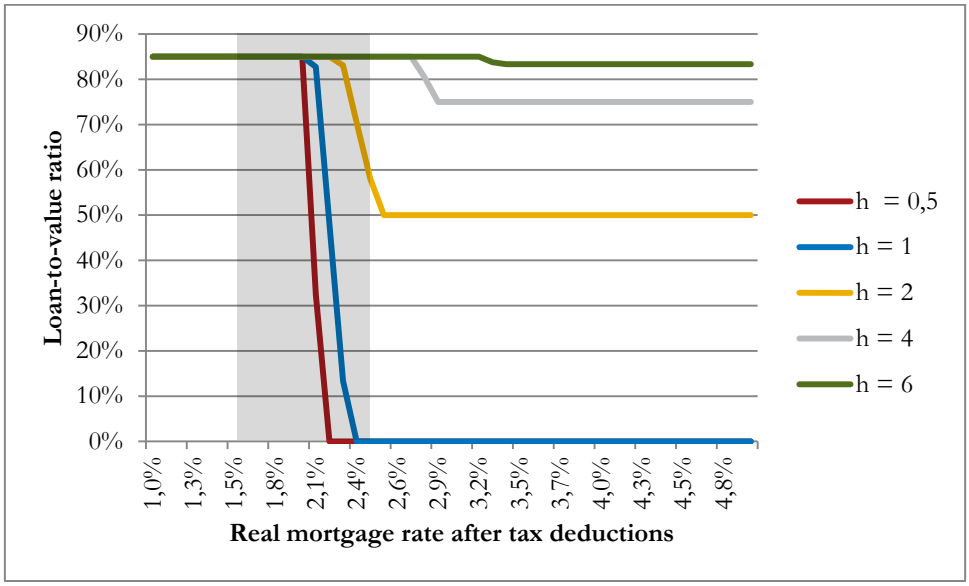
### Effects on optimal loan-to-value ratio of higher anticipated mortgage rate

The use of the above model to estimate the optimal choice of portfolio is sensitive to assumptions concerning the households' anticipated yield, interest rates and volatilities. These expectations are probably based on historical data. During the period 1997-2012, interest rates in Sweden were low and stable. The average variable mortgage rate after tax deductions and inflation was, for example, 1.6%. At the same time, housing was an attractive asset with a high average yield and low risk. If the households of today base their choice of portfolio on this historical data, it is probable that many of them will increase their risk exposure by an amount that exceeds what may be considered to be optimal in the future, in a more normal economic environment. In this section, we discuss the effect of changes in anticipated mortgage rate on the households' optimal choice of portfolio, with a focus on the loan-to-value ratio.

Diagram 1 shows the optimal loan-to-value ratio (it is assumed to amount to the maximum of 85% of the value of the home) for a relatively risk-averse household (*A*

= 10) at various levels of the variable real mortgage rate after tax deductions. Other anticipated yields and covariances in the model remain constant. At low real interest rates, all households, regardless of the value of *h,* choose to mortgage their home to the maximum extent. However, the results show that households are sensitive to higher interest rates and that it is the households with the lowest values for *h* that react the quickest to increased interest expense by reducing their loan-to-value ratio. Assuming a real mortgage rate of slightly more than 2.5% after tax deductions, for example, all households with an *h* that is lower than or equal to two choose to minimise their mortgaging.[10] At a real mortgage rate of about 3.3%, households with very high values for *h* choose to minimise their loan-to-value ratio.

**Diagram 1. Optimal loan-to-value ratio at various real mortgage rates**




During 1997 and 1998, the real variable mortgage rate after tax deductions was 3.9 and 3.4%, respectively (see Table A2 in the appendix). During 1999 and 2000, the rate was slightly lower, at 2.6% and 2.5%, respectively. After 2000, however, the average real mortgage rate has been less than 2% during every single year. In the Riksbank's Monetary Policy Report (October 2013), 5.2% to 6.5% is stated as the interval for the long-term level of the variable nominal mortgage rate.[11] This corresponds to an interval of slightly more than 1.60% to 2.50% for the real mortgage rate after tax deductions at a rate of inflation of 2%. Diagram 2 shows that within this relatively narrow interval (which is marked in grey in the figure), the households' optimal loan-to-value ratio varies significantly. Since the real mortgage rate during the period 1997-2012 was an average of 1.6%, we have been positioned at the lower end of this interval.

Expectations concerning the yield on the housing market should also be of significance to the households' choice of an optimal loan-to-value ratio. However, an

[10] However, households with a high *h* must maintain a high loan-to-value ratio even at high interest rates, because their own net worth is low. For example, a household with an *h* of two will not reduce its loan-to-value ratio to less than 50% by definition.
[11] The interval is based partly on the interval of 3.5–4.5% for the long-term repo rate and partly on an interval for the difference between the three-month mortgage rate and the repo rate of 1.7-2 percentage points.

analysis corresponding to the one referred to above shows that the yield and volatility of the housing market do not have any direct impact on the optimal loan-to-value ratio in the model, given a certain value of *h*.[12] Obviously, however, the anticipated yield and the volatility of housing market do have a direct effect on housing prices and thus on *h*. The anticipated yield on the housing market and the volatility of the yield are also of significance in respect of the probability of lock-in effects, such as those caused by the mortgage loan exceeding the value of the home. This question, among others, is analysed below.

## Risk of lock-in effects and mortgage prepayment decisions of households

Research shows that households with negative equity in their home, e.g. when the mortgage exceeds the market value of the home, tend to move to a lower extent than households with positive equity (see, for example, Ferreira et al., 2010). Households also tend to avoid selling their home if the market value is less than the purchase price (see Engelhard, 2003). This affects the probability of accepting new work at another location in connection with unemployment, for example. Accordingly, this has a negative effect on both the individual's possibilities of raising his/her income and on the economy in general. Research based on Swedish microeconomic data shows that there is a negative correlation between local property prices and the risk of various individuals becoming unemployed (the average correlation coefficient is minus 0.5), which means that the time at which the value of the home declines to less than the size of the mortgage loan tends to coincide with unemployment (see Jansson, 2013). This correlation strengthens the risks associated with a high loan-to-value ratio.

Using a basic model, the probability of the mortgage exceeding the market value of the home is determined by two factors, namely the anticipated yield on the home and the volatility of the yield. If the anticipated yield on the home is high, the probability of the home losing so much of its value that the mortgage will exceed the value of the home is low, all other factors remaining equal. The reverse applies to the volatility. If the volatility is high, the probability of negative equity rises, if all other factors remain equal.

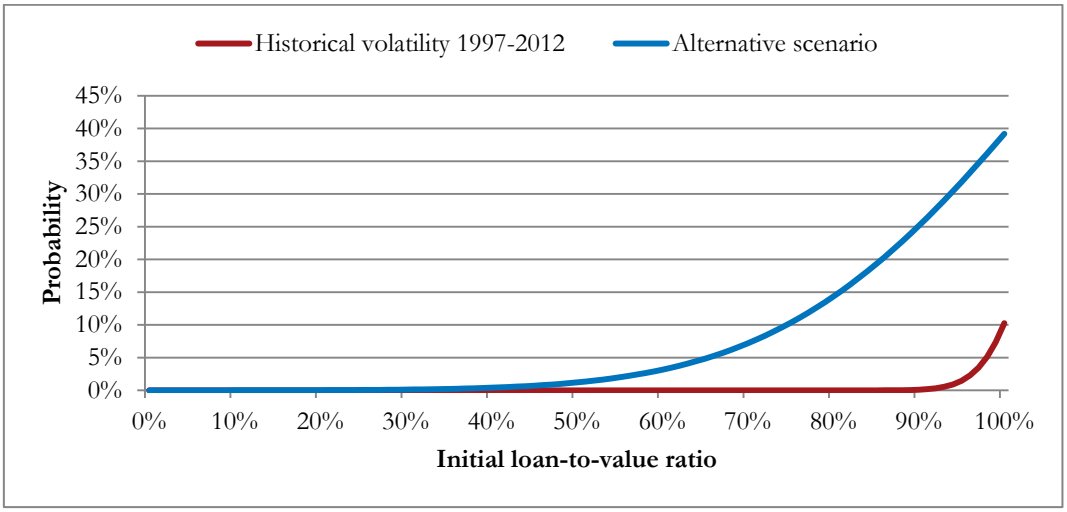
During the period 1997-2012, the standard deviation of the nominal yield on the property price index was only 3.7%. The standard deviation for individual single-family properties has been assumed to be somewhat higher, or more precisely 5.5%. Given the low volatility during this period, we have also used data from Englund et al. (2002) as an alternative scenario to estimate the volatility of the property market. Since Englund et al. use Swedish data from 1981 to 1993, years in the early 1990s when house prices were declining are included. They estimate that the standard deviation of the real yield during this period was 16.6% for the property price index and slightly more than 25% for individual single-family homes; in other words, significantly higher than the corresponding values during the period 1997-2012.[13]

Diagram 2 shows the probability of the value of the home falling to less than the mortgage in one year's time based on various initial loan-to-value ratios.[14] The anticipated nominal yield is assumed to be 6.9% (e.g. the average value during 1997-

[12] As a result of the fact that the consumption requirement of housing services is assumed to be exogenous in the model, the anticipated yield on the housing market is of no significance to the optimal choice of portfolio, given a certain value for *h*.
[13] We use the average variance calculated using an investment horizon of one and 10 quarters, respectively.
[14] The yield is assumed to be normally distributed and it is assumed that the household is not prepaying its mortgage.

2012) and the standard deviation of the yield is based on either data from 1997-2012 or on our alternative scenario (e.g. based on data from Englund et al.). The results show that the probabilities vary significantly at high loan-to-value ratios depending on the volatility in the property market that is assumed. When the volatility during 1997-2012 is used, the probability that the value of the home will fall to less than the size of the mortgage in one year's time is virtually nonexistent up to loan-to-value ratios of around 90%. Using the alternative scenario, the probability rises significantly earlier. At a loan-to-value ratio of, for example, 85%, the probability of negative equity in the home is around 20% after one year.

**Diagram 2. Probability that the value of the home will decline to less than the mortgage**




However, estimating the probability that the value of the home will fall to less than the size of the mortgage is mainly relevant for households with no or small holdings of financial assets. For households with greater financial wealth, the probability that the household's net worth will fall to less than zero, or alternatively less than 15% of the value of the home, is probably more relevant, since this could have negative implications for the household's propensity to relocate if the permissible mortgage on the new home is maximised at 85% of the value. These probabilities are reported in Table 4.[15] Households are assumed to optimise their portfolio given a relatively high risk aversion ($A$ = 10).

Given the volatility in the housing market during the period 1997-2012, the results show that the probability of negative net worth in one year's time is virtually zero regardless of the value of $h$. The probability of net worth falling to less than 15% of the value of the home is generally very low but rises to approximately 10% at $h$ = 6.67 (e.g. at a loan-to-value ratio of 85% and no financial assets). Using the alternative scenario for the volatility in the housing market (e.g. data from Englund et al.), however, these probabilities are significantly higher. For example, at a value of $h$ = 6.67, the probability is closer to 40% that the household will not have sufficient

[15] The probability that net worth will decline to less than 15% of the current value of the household's home is estimated here. The real restriction, however, is that the household's net worth will fall to less than 15% of the value of the new home. Given a general decline in housing prices, the value of the new home could very well decline to less than the value of the current home.

resources to pay the 15% down payment for a new home in one year's time. At the same time, the probability that net worth will be negative in one year's time is nearly 20%. In summary, these results show that the households' opinions of the future volatility in the property market may have a considerable impact on their incentives to reduce a high initial value of *h*, e.g. on the households' willingness to save.

**Table 4. Probability that the net worth of households will decline to less than zero or, alternatively, to less than 15% of the value of the home, given the optimal portfolio**

| Assumption regarding volatility in the property value | Probability that net worth will be less than | Value of *h* | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5 | 1 | 2 | 3 | 4 | 6.67 |
| Historical volatility | Zero | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1997-2012 | 15% of the value of the home | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 10.3% |
| Alternative scenario | Zero | 0.0% | 0.0% | 1.0% | 5.1% | 10.0% | 19.3% |
| | 15% of the value of the home | 0.0% | 0.0% | 4.2% | 15.0% | 24.5% | 39.2% |

The next step is to analyse the effects of a mortgage prepayment requirement. We are assuming that the requirement will lead to households being forced to prepay mortgages until such a time that they reach a loan-to-value ratio of 75%, which corresponds to a value of *h* that is equal to four, should the household have no financial assets. Accordingly, the effect of a mortgage prepayment requirement is that the high probabilities given a value for *h* that is higher than four, based on the alternative scenario, (see Table 4), will be gradually reduced as the household saves. Given that the household's value of *h* is lower or equal to four, however, a mortgage prepayment requirement would not have any negative impact on these probabilities (compare Table 4 and 5). The effect would probably be the opposite, which is due to the fact that if a mortgage prepayment requirement is enforced, the households will not be permitted to optimise their portfolios and retain a loan-to-value ratio in excess of 75%.

**Table 5. Probability that the net worth of households will decline to less than zero or, alternatively, to less than 15% of the value of the home, given a mortgage prepayment requirement**

| Assumption regarding volatility in the property value | Probability that net worth will be less than | Value of *h* | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5 | 1 | 2 | 3 | 4 | 6.67 |
| Historical volatility | Zero | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | * |
| 1997-2012 | 15% of the value of the home | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | * |
| Alternative scenario | Zero | 0.0% | 0.0% | 1.1% | 5.4% | 10.3% | * |
| | 15% of the value of the home | 0.0% | 0.0% | 4.4% | 15.5% | 25.1% | * |

## Retirement savings and mortgage prepayment decisions of households

According to the life-cycle model, there is a fundamental requirement to save for retirement during occupationally active years. In Sweden, retirement savings are largely managed by the state or via various occupational pension systems. For the national pension, 18.5% of the employee's pensionable income (pay and other taxable remuneration up to 7.5 income-base amounts) is allocated each year. At the same time, for most employees, 4–4.5% of income is allocated for occupational pensions. Accordingly, households generally have sizable pension assets. The question we analyse in this section is whether the large collective retirement savings in Sweden could serve as a partial explanation for the households' high indebtedness and low rate of mortgage prepayment. A related question is whether it is more advantageous to invest in private retirement savings than to prepay mortgages if the aim is to save for retirement in addition to the amount saved in collective systems. However, the obvious risk of having a large portion of retirement savings in these pension systems is that the savings are locked, e.g. that the household cannot divest pension assets during periods when they require extra liquidity.

Alessiey, Angeliniz and van Santen (2013) found, in a study using European data, that each SEK in pension assets leads to a decline in other types of assets by an average of 47 öre. The highest effect is found in the group of countries that includes Sweden, Denmark and the Netherlands. In these three countries, households reduce their other assets by a full 91 öre on average for each additional SEK they have in pension assets. However, they did not study specifically how this affects the households' loan-to-value ratios and mortgage prepayment behaviours.

Marekwica, Schaefer and Sebastian (2013) have developed a model through which they study consumption and portfolio choices over a life cycle with a focus on retirement savings, investments in housing and loan-to-value ratios. The hallmark of their model compared with other similar life-cycle models is that they assume that a given portion (6.3%) of labour income has been reserved for a specific retirement savings account. In the model, interest expense is deductible and retirement savings enjoy tax benefits, in common with the current situation in Sweden. They also assume a maximum loan-to-value ratio for the home ("mortgage ceiling") of 80% and a retirement age of 65 years. Their results indicate that the households with a higher portion of their total wealth invested in special retirement savings schemes optimally choose a higher loan-to-value ratio for their housing. More precisely, their model predicts that an increase of one percentage point of the household's total wealth that is kept in the retirement savings account leads to increase in the optimal loan-to-value ratio on the housing of between 0.18 and 1.37 percentage points depending on the household's current position in the life cycle. They found empirical support for their model in US data at a household level.

A related question concerns the choice between transferring funds to a private retirement savings scheme and paying off debts prior to retirement. According to current tax rules, it is permissible for up to SEK 12,000 annually per individual to be allocated to special retirement savings schemes and to be deducted from labour income. Pension disbursements are then taxed as labour income. At the same time, the interest on mortgage loans is deductible. The question that thus arises is which of these alternatives is the most advantageous for the specific individual once taxation effects are also included in the calculation.[16]

[16] Møller and Nielsen (2011) employ a similar rationale.

Assume that the interest rate on the mortgage loan is fixed and amounts to $r_B$ and that the yield on a retirement savings account with the same risk level as the mortgage loan is $r_L$ after yield tax.[17] The tax on both labour income and capital income is equal to $\tau$. The investment horizon is $T$ years. Amromin, Huang and Sialm (2007) propose the following strategy for generating what is called arbitrage profit, e.g. a risk-free gain:

1) Today:
    a. Refrain from SEK 1 in mortgage prepayment
    b. Deposit $X$ in a retirement savings thus reducing tax by $X\tau$
    c. Total cash flow: $1 - X + X\tau = 1 - (1 - \tau)X$
2) At the time $T$
    a. The retirement savings have grown to (after tax): $(1 - \tau)X(1 + r_L)^T$
    b. The loan principal has increased by $(1 + (1 - \tau)r_B)^T$
    c. Total cash flow: $(1 - \tau)X(1 + r_L)^{\mathrm{T}} - (1 + (1 - \tau)r_B)^T$
3) Arbitrage profit:
    a. $X$ is determined so that the cash flow at year $T$ amounts to zero:

$$X \equiv \frac{1}{1-\tau}\left(\frac{1+(1-\tau)r_B}{1+r_L}\right)^T$$

    a. Cash flow year $T$: $(1 - \tau)\frac{1}{1-\tau}\left(\frac{1+(1-\tau)r_B}{1+r_L}\right)^T (1 + r_L)^T - (1 + (1 - \tau)r_B)^T = 0$
    b. Cash flow today (*Marginal Arbitrage Profit*): $1 - (1 - \tau)X = 1 - \left(\frac{1+(1-\tau)r_B}{1+r_L}\right)^T$

If this strategy is applied, a risk-free arbitrage profit would be generated today assuming that $\left(\frac{1+(1-\tau)r_B}{1+r_L}\right) < 1$, e.g. that $(1 + (1 - \tau)r_B) < (1 + r_L)$. In other words, the yield on the retirement savings account must exceed the cost of the mortgage after tax deductions. If this condition has been fulfilled, the *Marginal Arbitrage Profit* increases in line with the investment horizon. This means, especially for relatively young households with many years remaining to retirement, that it is probably more advantageous to start saving in a pension scheme rather than to prepay mortgages, assuming that the aim is to save for retirement.

Naturally, this strategy is not risk-free in reality since it disregards future changes in interest rates and yields, liquidity requirements, etc. However, the above analysis provides an indication of the fact that households may find it optimal to increase their private retirement savings at the expense of reduced mortgage prepayment, and that the design of the Swedish tax system may actively contribute to such behaviour.

## Conclusions

The purpose of this memorandum is to study whether there are incentives for private households to abstain from prepaying mortgages. We have therefore chosen three reasons that households may be assumed to have for prepaying their mortgages and studied them in detail; the first reason is the general requirement of having to save,

[17] Private retirement savings are taxed at a rate of 15% of the tax base (government borrowing rate).

- the second reason is to save specifically towards the retirement pension and the third is the households' assessment of the probability of future major negative shocks, such as a substantial decline in housing prices.

A portfolio-selection analysis, based on data regarding the actual yields on real and financial assets during the period 1997-2012, shows that it is probably more advantageous for most households to save by investing in financial assets such as equity and fixed-income funds than to save by prepaying their mortgage. These results are a consequence of both low and stable mortgage rates and high average yields on real and financial assets during this period. However, a sensitivity analysis shows that the households' choice of an optimal loan-to-value ratio largely depends on the anticipated interest rate on the mortgage loan. Given an increase in the anticipated real variable mortgage rate by, for example, one percentage point compared with the average value during 1997-2012, the households' incentives to mortgage their homes decline significantly.

Swedish households generally have large pension assets. A high level of savings for retirement via collective systems probably reduces the households' incentives to prepay mortgages. The design of the Swedish tax system also leads to it probably being more advantageous to save for retirement through deductible private retirement savings schemes than by prepaying mortgages. The low volatility in the property market since the mid-1990s may also have led to the risk of a sharp future decline in the value of housing being regarded as low by households, thus reducing the households' incentives to save by prepaying their mortgage by an additional amount.

In summary, our analysis shows that the households' incentives to refrain from prepaying their mortgages are probably strong at present. However, this conclusion is based on the assumption that households expect that future mortgage rates, yields and volatilities will not deviate significantly from the average values during the period 1997-2012. It is, however, probable that deviations will occur and that households will therefore have to update their expectations successively. Given expectations of an increase in the interest rate on mortgages and expectations of higher volatility in fixed-income and housing markets, our analysis shows that households will have significantly stronger incentives to prepay mortgages compared with the situation today.

## References


Alessie, R., V. Angelini and P. van Santen (2013). "Pension Wealth and Household Savings in Europe: Evidence from SHARELIFE." Riksbank Working Paper Series No. 265.

Amromin, G., J. Huang and C. Sialm (2007). "The tradeoff between mortgage prepayments and tax-deferred retirement savings." *Journal of Public Economics* 91, 2014-2040.

Calvet, L., J. Campell and P. Sodini (2009). "Fight or Flight? Portfolio Rebalancing by Individual Investors," *Quarterly Journal of Economics* 124(1), 301-348.

Engelhardt, G. V. (2003). "Nominal loss aversion, housing equity constraints, and household mobility: evidence from the United States." *Journal of Urban Economics* 53 (1), 171 – 195.

Englund, P., M. Hwang and J. M. Quigley (2002). "Hedging Housing Risk." *Journal of Real Estate Finance and Economics* 24:1/2, 167-200.

Ferreira, F., J. Gyourko and J. Tracy (2010). "Housing busts and household mobility." *Journal of Urban Economics* 68 (1), 34 – 45.

Flavin, M. and T. Yamashita (2002). "Owner-Occupied Housing and the Composition of the Household Portfolio." *American Economic Review* 92(1), 345–62.

Jansson, T. (2013). "Housing choices and labor income risk." Riksbank Working Paper Series No. 272.

Marekwica, M., A. Schaefer and S. Sebastian (2013). "Life cycle asset allocation in the presence of housing and tax-deferred investing." *Journal of Economic Dynamics & Control* 37, 1110–1125.

Møller, M. and N. C. Nielsen (2011). "The occupational pension schemes of the future." SNS Förlag.

Riksbank (2013) Monetary Policy Report, October 2013, Riksbank.

# Appendix

### Table A1. Nominal yields on real and financial assets

| | Money market (Morningstar) | Fixed-income funds (Morningstar) | Equity funds (Morningstar) | Variable mortgage rate (Statistics Sweden) | Property index (Statistics Sweden) |
|---|---|---|---|---|---|
| 1997 | 3.5% | 6.6% | 17.6% | 5.7% | 7.0% |
| 1998 | 4.3% | 10.7% | 9.6% | 5.3% | 9.6% |
| 1999 | 2.7% | -0.3% | 57.9% | 4.4% | 9.2% |
| 2000 | 3.8% | 7.7% | -5.9% | 5.1% | 11.0% |
| 2001 | 3.8% | 3.1% | -8.4% | 5.3% | 8.0% |
| 2002 | 4.0% | 7.3% | -31.3% | 5.4% | 6.3% |
| 2003 | 3.1% | 4.4% | 19.5% | 4.3% | 6.6% |
| 2004 | 2.1% | 6.4% | 9.8% | 3.3% | 9.6% |
| 2005 | 1.5% | 4.0% | 38.4% | 2.7% | 9.6% |
| 2006 | 1.7% | 0.7% | 9.7% | 3.2% | 11.4% |
| 2007 | 3.0% | 1.2% | 7.7% | 4.4% | 10.7% |
| 2008 | 4.2% | 9.1% | -37.8% | 5.4% | 2.9% |
| 2009 | 1.8% | 3.2% | 37.6% | 2.1% | 2.0% |
| 2010 | 0.6% | 2.9% | 8.4% | 1.9% | 7.4% |
| 2011 | 2.1% | 7.5% | -13.4% | 3.8% | 0.7% |
| 2012 | 2.2% | 4.8% | 11.4% | 3.8% | -1.3% |

### Table A2. Real yields (after tax) on real and financial assets

| | Money market (Morningstar) | Fixed-income funds (Morningstar) | Equity funds (Morningstar) | Variable mortgage rate (Statistics Sweden) | Property index (Statistics Sweden) |
|---|---|---|---|---|---|
| 1997 | 1.9% | 4.1% | 11.8% | 3.4% | 4.9% |
| 1998 | 3.1% | 7.6% | 6.8% | 3.9% | 7.6% |
| 1999 | 1.5% | -0.6% | 39.9% | 2.6% | 6.7% |
| 2000 | 1.6% | 4.3% | -5.1% | 2.5% | 7.5% |
| 2001 | 0.2% | -0.3% | -8.1% | 1.2% | 3.7% |
| 2002 | 0.7% | 2.9% | -23.5% | 1.6% | 2.8% |
| 2003 | 0.2% | 1.1% | 11.5% | 1.1% | 3.2% |
| 2004 | 1.1% | 4.1% | 6.4% | 1.9% | 7.1% |
| 2005 | 0.6% | 2.4% | 26.3% | 1.5% | 7.1% |
| 2006 | -0.2% | -0.9% | 5.4% | 0.9% | 7.4% |
| 2007 | -0.1% | -1.3% | 3.1% | 0.8% | 6.0% |
| 2008 | -0.5% | 2.8% | -28.9% | 0.3% | -1.1% |
| 2009 | 1.6% | 2.6% | 26.7% | 1.8% | 1.9% |
| 2010 | -0.8% | 0.8% | 4.6% | 0.1% | 4.4% |
| 2011 | -1.1% | 2.6% | -11.7% | 0.0% | -2.0% |
| 2012 | 0.6% | 2.4% | 7.0% | 1.8% | -1.9% |

**Table A3. Optimal choice of portfolio given nominal yields during 1997-2012.**

| | | $A = 1$ | $A = 2$ | $A = 4$ | $A = 8$ | $A = 10$ |
|---|---|---|---|---|---|---|
| $h = 0.5$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 46% | 70% | 83% | 89% | 90% |
| | Equity funds | 54% | 30% | 17% | 11% | 10% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 1$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 45% | 71% | 85% | 92% | 93% |
| | Equity funds | 55% | 29% | 15% | 8% | 7% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 2$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 42% | 74% | 91% | 99% | 100% |
| | Equity funds | 58% | 26% | 9% | 1% | 0% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 4$ | Money market | 0% | 0% | 0% | 0% | 0% |
| | Fixed-income funds | 30% | 87% | 100% | 100% | 100% |
| | Equity funds | 70% | 13% | 0% | 0% | 0% |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |
| $h = 6.67$ | Money market | * | * | * | * | * |
| | Fixed-income funds | * | * | * | * | * |
| | Equity funds | * | * | * | * | * |
| | Mortgages (loan-to-value ratio) | -85% | -85% | -85% | -85% | -85% |