

Economic commentary

Household indebtedness: a regional perspective

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The indebtedness of households varies considerably across regions

Credit granted to the household sector has doubled since 2007.² At the same time, the indebtedness of households varies considerably across regions of Sweden. In this Economic Commentary, we document this variation in indebtedness using different measures. Regional differences in indebtedness can be attributed to, among other things, both levels and growth rates of the variation in population, incomes, the supply and demand of housing and the associated price level on housing.

Studying the regional differences in household indebtedness is interesting for a number of reasons. First, with debt levels differing between regions, some regions may be more sensitive to changes in macroeconomic conditions (such as interest rates and asset prices) than others. For instance, the same change in interest rates may have different implications for consumption spending in a high-debt region relative to a low-debt region.

Second, as aggregate outcomes of different variables can be obtained by adding up regional developments, taking regional differences into account may produce more accurate forecasts of how the economy will respond to changes in macroeconomic conditions.

Third, recent macroprudential policy in for example Norway and Denmark has explicitly targeted the big cities, where house price growth has been particularly high. In Oslo, this policy takes the form of a 60 per cent loan-to-value (LTV) limit on secondary homes, as well as a lowering of the credit volume granted to borrowers which do not meet amortisation, LTV or debt-to-income (DTI) requirements (Finansdepartementet, 2016). In Copenhagen and Aarhus, the Danish Risk Council recommended to limit housing loans at variable rates or with deferred amortisation to high-DTI borrowers (Det Systemiske Risikoråd, 2017). And even though macroprudential policy in Sweden so far has not targeted borrowers in big cities explicitly, macroprudential policies such as LTV limits and amortisation requirements may impact these borrowers to a greater extent.

Fourth, recent research shows that regional differences in housing equity in the United States also impact the monetary policy transmission mechanism (Beraja et al, 2017). In particular, the monetary stimulus during the recession impacted most those regions with the smallest increases in unemployment and the smallest

¹ We would like to thank our colleagues at the Riksbank for their valuable comments on previous drafts.

² Credit to households refer to all credits granted to the household sector in Sweden between January 2007 and March 2017 (Table 7.1.1 from Financial Market Statistics, Statistics Sweden). In April 2017, monetary financial institutions' credit granted to the household sector was a total of SEK 3 602 billion.

Credit to the household sector has doubled since 2007. At the same time, the indebtedness of households varies considerably across regions of Sweden. In this Economic Commentary, we describe the variation in indebtedness by municipality and by type of property. Households with single-family homes are more indebted than households living in tenant-owned apartments. We show that the share of the population with mortgages, the average debt levels and average debt-to-income ratios are all highest around the big cities, where housing prices have been increasing the most. At the same time, the loan-to-value ratio for single-family home owners is, on average, lowest in the big cities. We also document that rapid housing price increases in recent years in the metropolitan areas have contributed to a large increase in households' debt-to-income ratios, and to smaller declines in loan-to-value ratios.

declines in house prices, suggesting that interest rate cuts were unable to help borrowers in the most distressed regions. Beraja et al. (2017) conclude that it is important for monetary policy decisions to track this variation in house prices and debt.

In this Economic Commentary we show the regional variation of indebtedness based on data from the eight largest banks in Sweden.³ More specifically, we provide municipality-level statistics for:

- The share of the population having mortgages
- The share of mortgages collateralised by tenant-owned apartments
- Average DTI of households by property type
- Average mortgage debt of households by property type
- Average market value and LTV of households with single-family homes

All measures of indebtedness vary considerably across regions of Sweden. As we have data on indebtedness for only a limited number of years (2010-2016), we focus on the differences between municipalities at a given point in time.⁴

In this economic commentary, we find that the share of the population having mortgages, the average amount of mortgage debt and the average DTI ratio for indebted households are positively correlated. In other words, in municipalities with a high fraction of indebted households, average mortgage debt tends to be high as well, as is the DTI ratio. The metropolitan areas of Stockholm and Gothenburg, as well as parts of the west coast, are most indebted by each of these measures.

The positive correlation between DTI and average mortgage debt might seem obvious. Yet, previous Riksbank Economic Commentaries⁵ have shown that DTI is highest for low income households. For low income households, a high DTI does not necessarily translate into high debt amounts. If some regions had a higher share of low-income households, the relationship might in fact be negative. Our finding therefore suggests that income amongst mortgage holders is relatively evenly distributed across regions.

Our analysis of LTV levels in Sweden is restricted to single-family homes only, as valuations of tenant-owned apartments are not available in general. We find that average LTV ratios for single-family homes in 2016 are lowest in the big cities, and document a negative correlation between the regional average LTV and DTI ratios. However, we also show that households with higher LTV ratios tend to have higher DTI ratios, giving a discrepancy between the LTV-DTI correlation when using regional averages (for which we find a negative correlation) versus household-level data (for which the same correlation is positive). The main takeaway is that the seemingly negative correlation between LTV and DTI when looking at municipality-level averages should not be interpreted as a sign of diversification; instead, households with high DTI ratios also have high LTV ratios, making them vulnerable to both increases in interest rates as well as house price declines.

We emphasize that we only study correlations here, and do not take a formal stand on whether rising housing prices cause increasing indebtedness, or whether an increase in debt appetite (for instance, due to low interest rates) has further increased housing prices. Debt and house

³ For more information about this data as well as descriptive statistics, see Ölcer and van Santen (2016).

⁴ We refer to the numerical data spreadsheet for additional variables.

⁵ See Winstrand and Ölcer (2014), Alfelt and Winstrand (2015), van Santen and Ölcer (2016) and Ölcer and van Santen (2016).

prices interact in multiple ways, the mechanisms behind which are difficult to disentangle using the data at hand.

The share of households with debt is increasing

A straightforward way to measure household indebtedness is the share of the population in a certain region with debt. According to our data, the share of the adult population with mortgages nationwide has increased from 41.5 per cent in 2010 to 42.9 per cent in 2016. By July 2016, over 3 million individuals had mortgages.

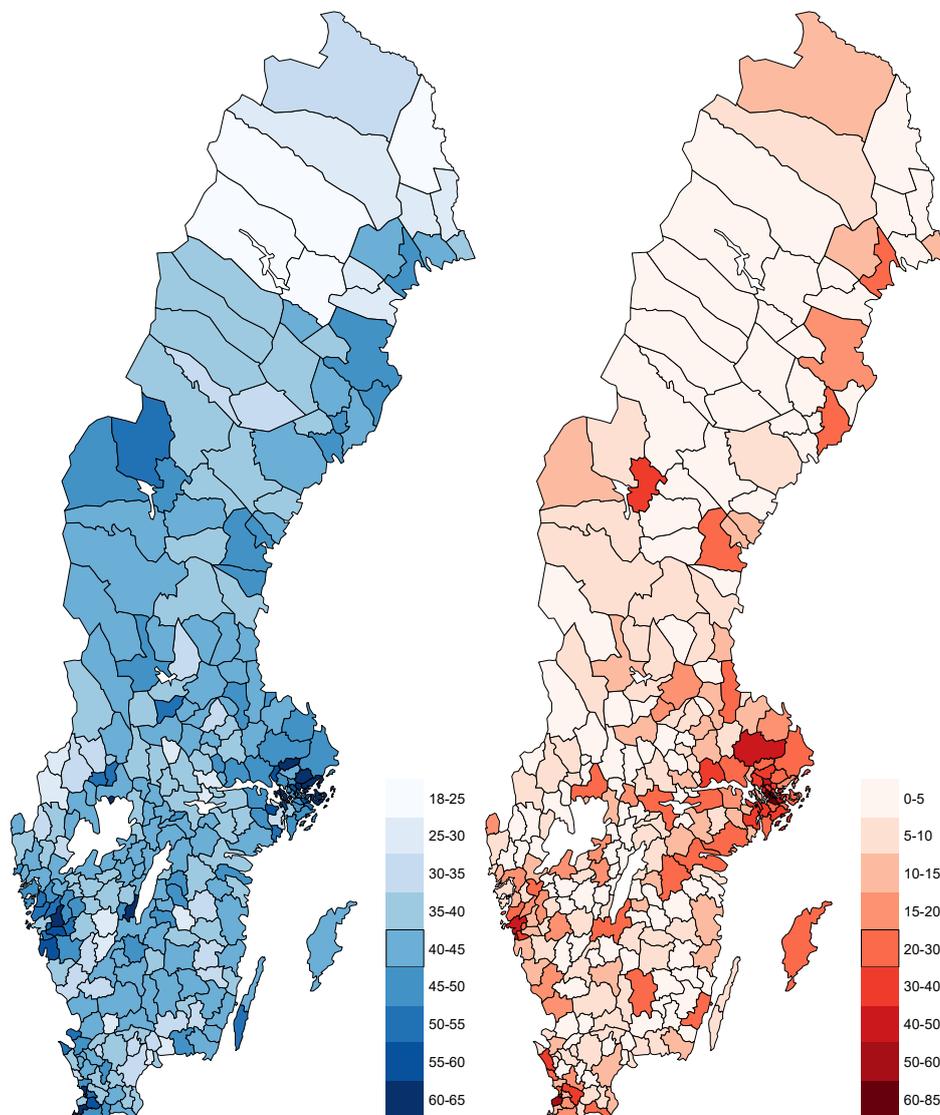
Figure 1a shows the number of individuals living in households with mortgages, relative to the total adult population (aged 18 or above) in the municipality, as obtained from Statistics Sweden (2017a). The highest shares, above 60 per cent, are found around Stockholm, Gothenburg, and Malmö. In the northern parts of Sweden, the same ratio is as low as 20 per cent. Note that individuals without mortgages might be either renting or owning their property outright.

Even bordering municipalities can have drastically different mortgage penetration rates. For instance, while the municipality of Malmö has 36 per cent of its adult population indebted, the same statistic in neighbouring municipality Vellinge is 64 per cent, which partially stems from a difference in the availability of rentals in these municipalities.

Figure 1b shows what share of the mortgages in a given municipality is collateralised by tenant-owned apartments, the remainder being collateralised by single-family homes. As tenant-owned apartments are much less common in smaller cities and in the countryside, the share of mortgages collateralised by tenant-owned apartments is higher around large and medium sized cities. Since 2010, the share of mortgages collateralised by apartments has increased from 23 per cent to 28 per cent, partly reflecting faster population growth in the big cities.

Figure 1. Mortgage holders and collateral by municipality

a. Individuals with mortgages, per cent of adult population **b. Share of mortgages collateralised by tenant-owned apartments, per cent**



Note. Data is from July 2016. The map on the left hand side shows the percentage of individuals living in households with mortgages, relative to the adult population in that municipality. The map on the right hand side shows the percentage of mortgages collateralised by tenant-owned apartments in the municipality, the rest is mortgages collateralised by single family houses.
Sources: Statistics Sweden and the Riksbank.

Debt-to-income ratios are highest in the big cities

Figure 2 shows average DTI ratios in 2016, separately for households with single-family homes (Figure 2a) and for households with tenant-owned apartments (Figure 2b). In 211 out of 290 municipalities, the average DTI level is higher for households living in single-family homes than for households living in tenant-owned apartments, with an average (median) difference of 32 (49) percentage points. However, one cannot directly compare debt between houses and apartments, as the latter typically have additional debt through the housing association. Moreover, the housing stock in many municipalities consists of mostly houses (see Figure 1b), so that for smaller municipalities with few apartments, the average DTI is estimated with greater uncertainty.

Figures 2a and 2b show that DTI levels are highest around the big cities. Around Stockholm, for instance, average DTI exceeds 500 per cent in some municipalities. Such high DTI ratios may imply that the household spends a significant amount of their income on servicing their debt. That also means that the household may be sensitive to changes in the interest rate, which might lead it to reduce its consumption when interest rates rise.

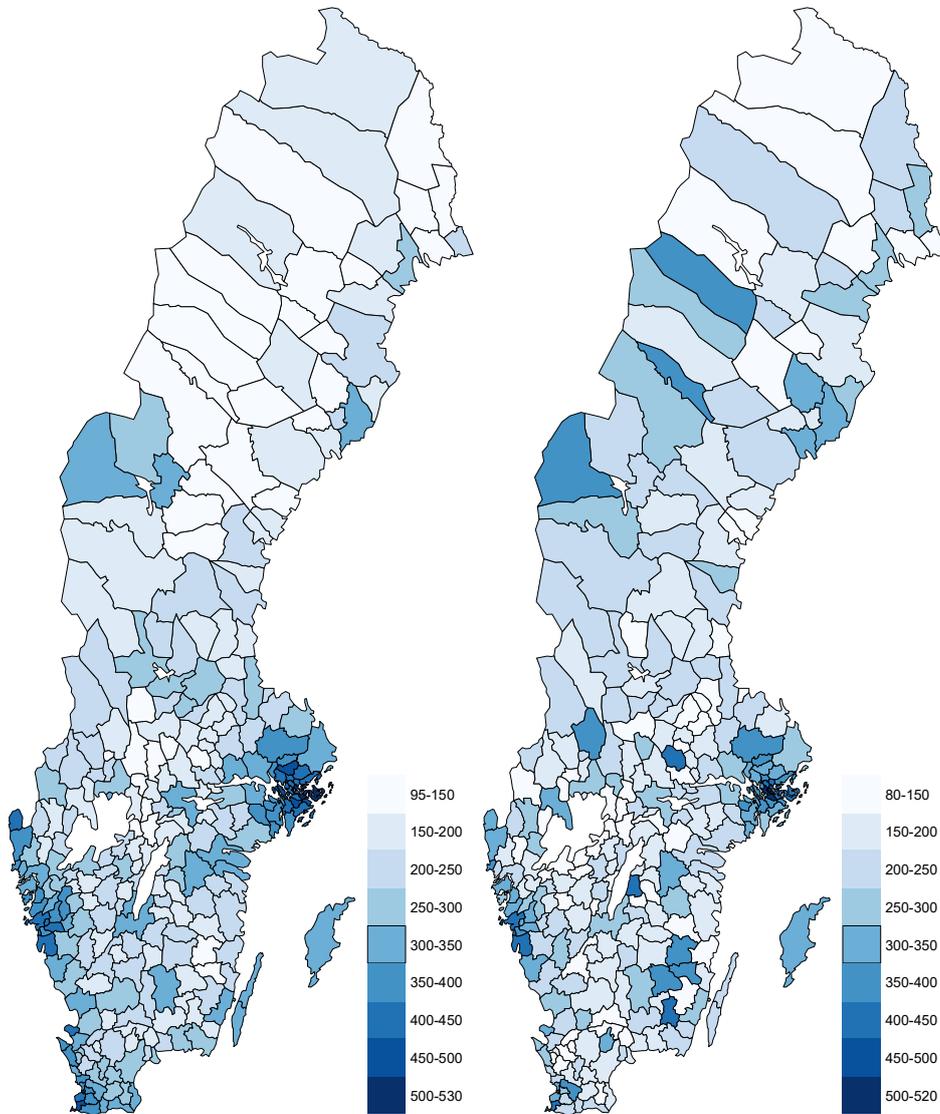
Around the big cities, Figure 1a also showed that a higher fraction of the population has any mortgage debt. Across municipalities in 2016, the correlation between the share of the adult population with mortgages and the average DTI ratio equals 0.4.⁶ Put differently, the municipalities with a greater share of people indebted also tend to have higher debt ratios.

The data additionally suggest that this relationship is partially stemming from differences in housing prices, as the correlation between the debt penetration rate and the DTI ratio is stronger in areas with higher housing prices. In these areas, one may imagine that fewer households are able to afford buying their property without taking a mortgage. In addition, the amount borrowed is also higher in the areas where housing prices are high. These highly indebted regions are therefore presumably most vulnerable to rising interest rates, since a larger share of the population is at risk of facing higher interest payments relative to their income.

⁶ We use population weights to arrive at the correlation of interest, to reflect the fact that the 290 municipalities are vastly different in size. The unweighted correlation equals 0.60. Very similar correlations are obtained when employing different measures of the intensive margin, such as median or average mortgage debt or the median DTI ratio.

Figure 2. Debt to income by municipality and type of property

a. Average DTI for households with single-family homes, b. Average DTI for households with tenant-owned apartments, per cent



Note. Data is from July 2016. For the map on the left hand side, the colours indicate the average DTI of households with single-family homes in the municipality. For the map on the right hand side, the colours indicate the average DTI of households with tenant-owned apartments in the municipality.

Source: The Riksbank

The amount of mortgage debt is highest around Stockholm

The DTI ratio is a useful measure of indebtedness, as higher-income households are likely to buy bigger houses financed by larger mortgage loans⁷, and hence scaling by income corrects this feature. However, taking a mortgage loan specifies a non-contingent promise to repay, even when income should fall, for instance in a recession.

Figure 3 plots the average nominal amount of debt, separately for households with a single-family home (Figure 3a) and those with a tenant-owned apartment (Figure 3b). The ten municipalities with the highest average gross debt position based on mortgages secured by single-family homes are all found around Stockholm, with the municipality of Danderyd having the highest level at SEK 3.8 million on average in July 2016. A similar picture emerges for mortgages secured by tenant-owned apartments: 9 out of the 10 municipalities having the highest average mortgage debt are found around Stockholm. The municipality of Stockholm itself has the highest level, at SEK 1.9 million per July 2016.

A noteworthy finding is that the nominal amount of mortgage debt is more unevenly distributed across municipalities than is the DTI ratio. For instance, average debt levels for households living in tenant-owned apartments range between around 150,000 SEK to 1.9 million SEK, so that the most-indebted municipality has more than 12 times the debt than the least-indebted municipality. For DTI, the same ratio between the highest and lowest indebted municipality equals 6. The fact that debt is more unevenly distributed than is the DTI ratio means that high-income households have larger debts. Put simply, the high debt levels around Stockholm and Gothenburg can, to a large extent, be explained by higher income levels.

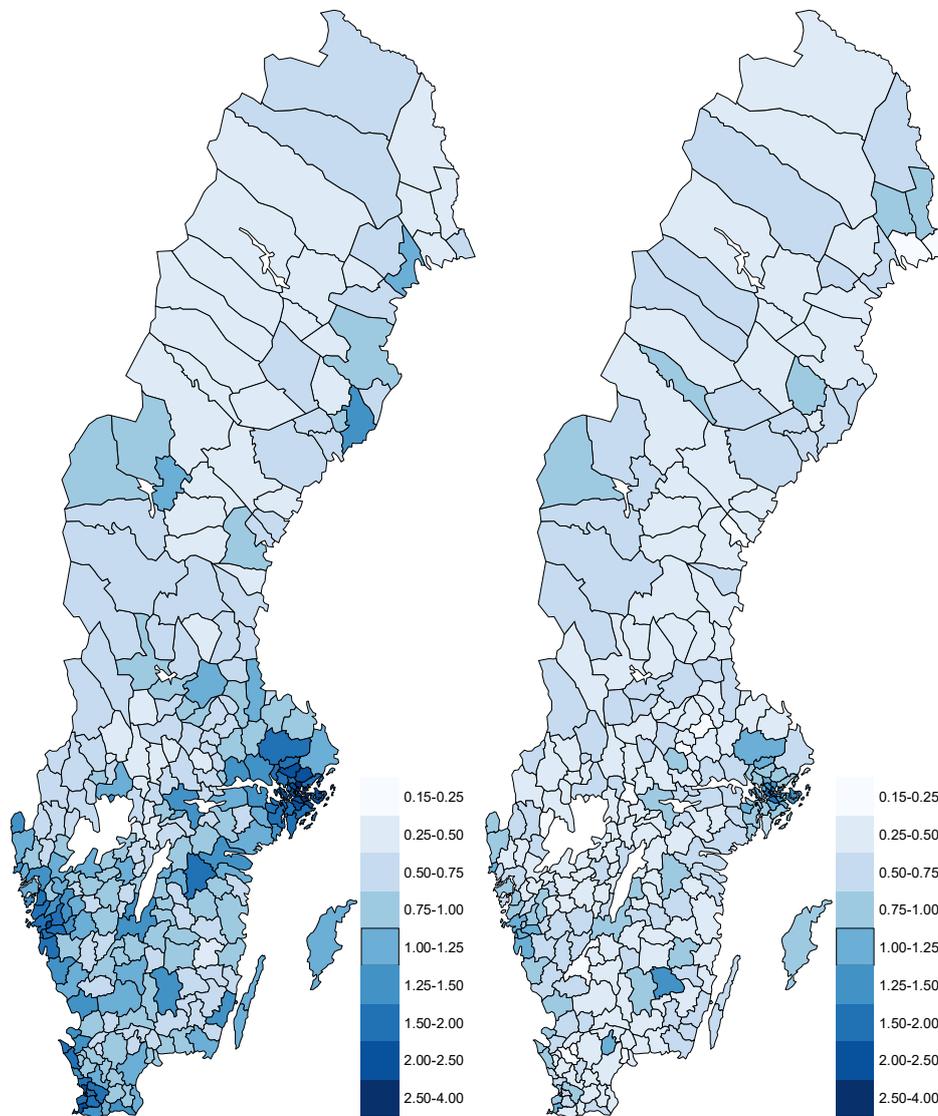
Municipalities with high average debt amounts typically also have high DTI ratios. The correlation between the average DTI ratio and average mortgage debt equals 0.97 for tenant-owned apartments, and 0.95 for single-family homes. As mentioned earlier, this positive correlation between DTI and average mortgage debt might seem obvious, although, as previous Riksbank Economic Commentaries have shown, average DTI is highest for households in the lowest income groups. Yet for a low income household, a high DTI does not typically translate into high mortgage debt. If some regions had a higher share of low-income households, the relationship between DTI and average mortgage debt might in fact be negative. The positive relationship that we find therefore suggests that income amongst mortgage holders is relatively evenly distributed across regions. Average household disposable income amongst mortgage holders in 2016 ranges between 26,000 SEK/month and 72,000 SEK/month for the lowest-income and highest-income municipalities. While this difference is sizeable, it confirms that average income is much more evenly distributed than is debt.

⁷ Financial wealth correlates with income, but the correlation is not very strong, as otherwise high-income households would not necessarily need larger loans.

Figure 3. Average mortgage debt by type of property

a. Single-family homeowners, SEK million

b. Apartment owners, SEK million



Note. Data is from July 2016. The map on the left hand side shows average household mortgage debt (in million kronor) for single-family homes, by municipality. The map on the right hand side shows average household mortgage debt (in million kronor) for tenant-owned apartments, by municipality.

Source: The Riksbank.

Housing prices and mortgage debt are strongly related

The high levels of indebtedness around the big cities are obviously related to the relatively high housing prices in those same regions. Between 1986 and 2016, the national average real price of single-family houses increased by 220 per cent. During the same period, the increase was more than 350 per cent in Stockholm, but much less pronounced in other parts of Sweden (Riksbank, 2016, chart 2:2). Apartment prices in Stockholm have increased by 600 per cent in real terms during the same period. As debt and house prices move in tandem, we also study household debt in relation to property values, and how this varies by region.

Table 1. Debt and housing prices, by region and type of property

Housing prices	Apartments		Houses	
	Price level	Price growth	Price level	Price growth
Region	2016	2010-2016	2016	2010-2016
Stockholm	3 603 000	66 %	5 579 000	47 %
Gothenburg	2 575 000	72 %	4 151 000	41 %
Malmö	1 625 000	33 %	3 420 000	20 %
Rest of the country	1 053 000	75 %	1 920 000	34 %
Country	2 200 000	68 %	2 772 000	37 %

Mortgage debt	Apartments		Houses	
	Debt level	Debt growth	Debt level	Debt growth
Region	2016	2010-2016	2016	2010-2016
Stockholm	1 628 000	43 %	2 059 000	39 %
Gothenburg	1 164 000	47 %	1 772 000	38 %
Malmö	849 000	23 %	1 638 000	29 %
Rest of the country	710 000	51 %	1 016 000	34 %
Country	1 184 000	42 %	1 303 000	36 %

Note. The top panel of this table shows average transaction prices in 2016 and nominal growth rates of average transaction prices between 2010 and 2016, for tenant-owned apartments and single-family houses, respectively, in different regions of the country. The bottom panel shows average mortgage debt in 2016 and nominal growth rates of average mortgage debt between 2010 and 2016. A region corresponds to a Metropolitan Area, which groups together several municipalities (12, 13 and 26 municipalities for the Metropolitan Area of Malmö, Gothenburg and Stockholm, respectively). All remaining municipalities are averaged in the row labelled "Rest of the country".

Sources: Statistics Sweden (2017b,c) and the Riksbank.

Statistics on house price levels and growth rates from Statistics Sweden (2017b,c)⁸ in Table 1 reveal that average house prices in 2016 are highest around Stockholm for both apartments and houses, followed by Gothenburg and Malmö. At the same time, prices of apartments have increased more outside the largest cities, percentage-wise. For houses, debt and prices have grown at approximately the same rate between 2010 and 2016, with the exception of the Malmö region, where debt growth exceeded house price growth. For apartments, prices increased faster than debt during the same years.

We use our household-level data to compute LTV ratios, expressing mortgage debt as a percentage of the market value of the property. A high LTV means that if the value of the property falls, the household may end up having loans that are larger than the value of the property, i.e. be "under water". The extent to which households are under water has been

⁸ The statistics shown are average transaction prices and their growth rates, and are therefore not adjusted to quality differences, as is commonly done in house price indices published by Valueguard and Statistics Sweden. The differences in growth rates computed using average transaction prices or indices are relatively minor.

shown to matter for household consumption and deleveraging, residential mobility and unemployment, and the recovery from financial crises (see for example Dynan (2012), Mian, Rao and Sufi (2013) and Sterk (2015)).

The data includes the tax-assessed value of owned properties, for single-family homes. We combine this assessed value with regional statistics on the ratio between sales prices and tax-assessed values, the purchase-price coefficient⁹ from Statistics Sweden (2016c), to approximate the market value of single-family homes.¹⁰ Finally, we divide the household's mortgage debt secured by single-family homes by this market value to arrive at a household-level LTV ratio. We disregard households with tenant-owned apartments in what follows, as valuations of apartments are not available to us. Since tenant-owned apartments are most common around larger cities, the LTV ratios shown in this Economic Commentary must be interpreted in light of these data limitations.

Figure 4a depicts the average market value of single-family homes in 2016 (i.e. the average of the denominator in the LTV ratio). These average market values range between a low of 387,000 SEK in the municipality of Åsele, to a high of 11.6 million SEK in Danderyd. The average market value nationwide in 2016 is 2.9 million SEK, slightly higher than the average transaction price shown in Table 1, as we have market values only for single-family homeowners with debt, but not for outright owners. This figure confirms that housing prices and debt positions are strongly correlated, with a coefficient of 0.98.

Figure 4b shows the average LTV ratio by municipality in 2016. On average, 46.9 per cent of the value of housing in 2016 is financed by mortgages, the remainder being home equity and, to some extent, unsecured credits. Since 2012, the average LTV ratio in Sweden declined from 60.3 to 46.9 per cent, reflecting house price growth, which increases home equity value as long as the household does not move or refinance. From 2010-2012, when housing prices remained constant, the ratio increased from 49.5 per cent to 60.3 per cent.

Geographically, the LTV ratio is unevenly distributed in Sweden. Unlike the other measures of debt shown in Figures 1, 2 and 3, however, the LTV is lowest around the big cities. Across municipalities in 2016, average DTI (for households with single-family homes) and average LTV are negatively correlated, with a correlation coefficient of -0.64.¹¹ Finansinspektionen's mortgage market survey, which is based on new mortgage borrowers, also documents a negative correlation on a national level between average DTI and average LTV in 2016 (FI, 2017, Figures 1 and 2).¹²

The negative correlation between average LTV and average DTI at the municipality level may appear surprising at first sight. After all, one might expect that households with high debt have both high LTV and high DTI levels, giving a positive correlation. Indeed, at the household level, we do find this positive correlation: DTI of households with single-family homes has a correlation coefficient of 0.39 to their LTV ratio, in 2016. For new mortgage borrowers, Finansinspektionen documents a correlation of 0.19 (FI, 2017, Diagram B2).

⁹ This purchase-price coefficient is available on an annual basis at the municipality level only, and hence does not take within-municipality variation (between households or during the year) into account. This could be a source of measurement error in the LTV ratio, especially so for small or medium-sized municipalities in which few homes are sold in a given year, which makes estimation of this coefficient potentially imprecise.

¹⁰ The market value of a specific property is computed as the purchase-price coefficient of the municipality in a given year, times the tax-assessed value of that specific property in the same year. The average market value by municipality is very similar to using average transaction prices for houses that were sold, as reported by Statistics Sweden (2017c) for the years 2010-2016.

¹¹ These correlations are similar when we look at the median DTI and LTV ratio, by municipality, or at other years between 2010 and 2015. The correlation is computed at a single-point in time, but is obviously affected by past house price and debt dynamics.

¹² It would be interesting to compare the average LTV ratios of first-time buyers and repeated buyers, since the latter have seen their existing home appreciate much in value in recent years. Unfortunately, the data does not contain precise enough information to make that distinction.

To understand where the discrepancy between correlations computed at the household level and those at the municipality level stem from, we note that the household-level correlation is equal to the sum of the correlation between municipalities and the correlation within municipalities. More precisely, it is statistically possible to decompose the correlation between DTI and LTV at the household level into the correlation within a municipality, and a correlation between municipality averages. While the correlation between municipalities is negative, as discussed above, our data shows that, for all 290 municipalities, the within-municipality correlations are positive. The Appendix demonstrates this exercise in more detail. The main takeaway is that the negative correlation between LTV and DTI when looking at municipality-level averages should not be interpreted as a sign of diversification; instead, households with high DTI ratios also have high LTV ratios, making them vulnerable to both increases in interest rates as well as house price declines.

Finally, Table 2 shows the development of median LTV and DTI ratios of single-family homeowners in different regions. Median LTV ratios in 2016 are virtually the same for Sweden as a whole as they were in 2010, but different regions have developed very differently: in Stockholm and outside the big cities, LTV has declined. In Gothenburg and especially Malmö, however, LTV has increased. In Malmö, the negative developments on the Copenhagen-Malmö housing market have increased median LTV by 7 percentage points. In contrast, median DTI has increased everywhere, at roughly similar rates across regions. The table points out that the rapid housing price increases in recent years in Stockholm and outside the major cities have contributed to a large increase in household indebtedness, and to much smaller declines in LTV. For Gothenburg and Malmö, LTV ratios have even increased, especially so in Malmö.

Table 2. Development of LTV and DTI ratios, by region

Region	Median LTV			Median DTI		
	2010	2016	% change	2010	2016	% change
Stockholm	42	40	-4,6	341	382	12,1
Gothenburg	42	43	1,3	319	356	11,8
Malmö	41	48	16,6	306	335	9,5
Rest of the country	49	47	-2,8	195	214	9,8
Country	47	46	-2,1	225	252	12,2

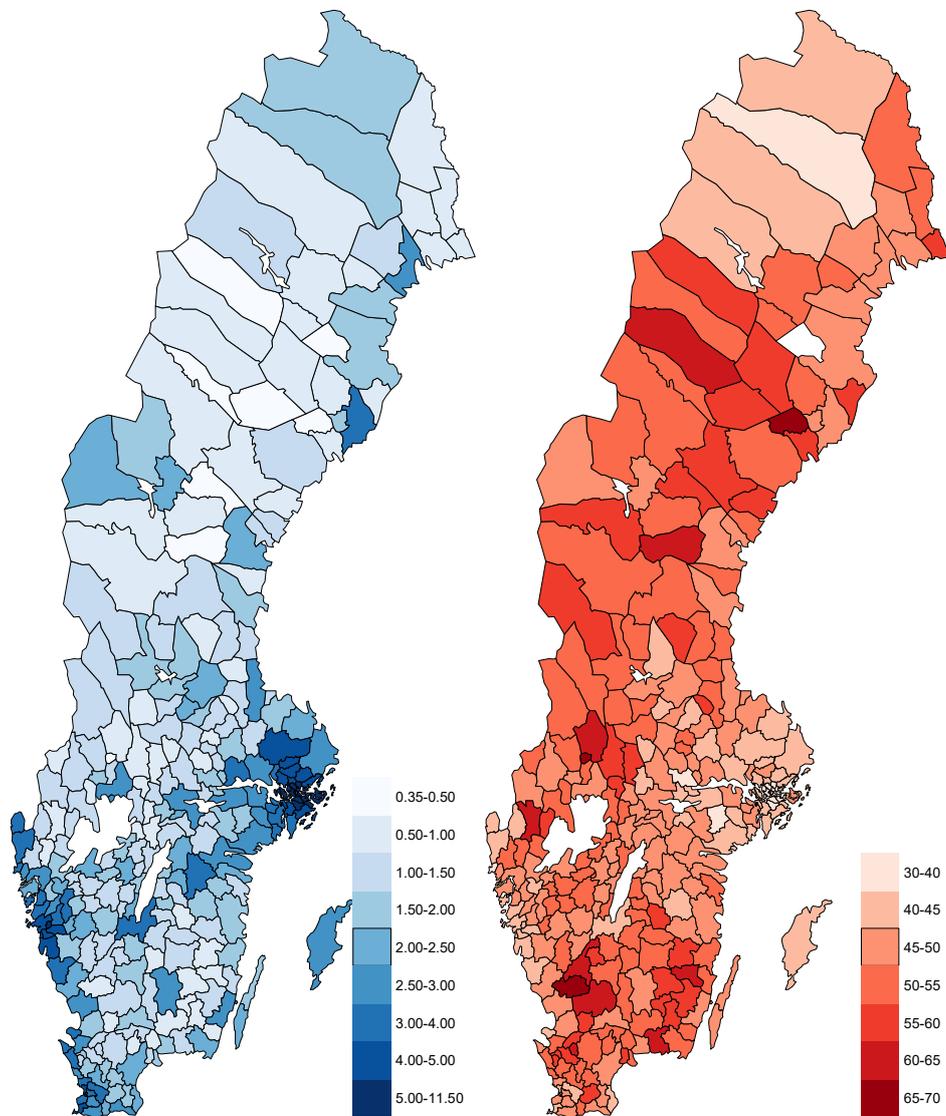
Note. The table shows median LTV and DTI ratios amongst households with single-family homes, in different regions of the country. A region corresponds to a Metropolitan Area, which groups together several municipalities (12, 13 and 26 municipalities for the Metropolitan Area of Malmö, Gothenburg and Stockholm, respectively). All remaining municipalities are averaged in the row labelled "Rest of the country".

Sources: Statistics Sweden (2017b) and the Riksbank.

Figure 4. Housing prices and mortgage indebtedness

a. Average market value, SEK million

b. Average LTV, per cent



Note: Data is from 2016. For the map on the right hand side, the colours indicate the average market value of single-family homes, by municipality. For the map on the left hand side, the colours indicate the average LTV ratio for households with single-family homes, by municipality.

Sources: Statistics Sweden and the Riksbank.

Concluding remarks

This Economic Commentary has presented regional statistics on household indebtedness. Indebtedness, as measured by DTI, the amount of debt or the share of the population indebted, is highest in the regions around the big cities. High levels of housing prices imply that, on average, urban households have lower LTV ratios. At the same time, high-DTI households tend to have high LTV ratios as well, and this relationship holds in the entire country.

This may imply that households in the regions around the big cities are more sensitive to changes in macroeconomic conditions (such as interest rates and asset prices) than others. Given the importance of these regions for macroeconomic aggregates, it is important to look at the regional differences when discussing the consequences of adverse borrowing conditions on real economic outcomes.

Households have become more indebted in two ways in recent decades: the number of households with debt has risen (both in absolute numbers as well as relative to the population), and average debt has increased both in terms of levels and relative to income. As most mortgages have adjustable rates, this makes household sensitive to changes in the interest rate as well as in income. This Economic Commentary has further shown that the macroeconomic risks posed by increasing household indebtedness are elevated around the cities of Stockholm, Gothenburg and Malmö. Given the significance of these regions for macroeconomic outcomes, tracking the development of the housing and mortgage market remains important.

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Appendix

The correlation between two variables, y and x , in a data set with a group structure, can be decomposed as follows:

$$Corr(y, x) = \sum_{k=1}^K \frac{N_k - 1}{N - 1} Corr_k(y, x) \frac{SD_k(y)}{SD(y)} \frac{SD_k(x)}{SD(x)} + \sum_{k=1}^K \frac{N_k}{N - 1} \frac{(\bar{y}_k - \bar{y})(\bar{x}_k - \bar{x})}{SD(y)SD(x)} - \frac{N}{N - 1} \frac{(\bar{y} - \bar{y})(\bar{x} - \bar{x})}{SD(x)SD(x)}$$

In our application, y denotes the LTV ratio, x denotes the DTI ratio, k indexes municipalities for a total of $K = 290$ municipalities in Sweden, N_k equals the number of households in municipality k , $Corr_k(y, x)$ denotes the within-municipality correlation between the LTV and DTI ratios, SD_k is shorthand for the standard deviation within municipality k , and SD is the standard deviation for all households in Sweden. Finally, \bar{y}_k denotes the average LTV ratio in municipality k , \bar{y} denotes the (unweighted) average of \bar{y}_k across all municipalities, and \bar{y} the average LTV ratio for all households in Sweden, and similarly for x .

Intuition for this expression can be seen as follows. The first term on the right hand side denotes the aggregate of within-municipality correlations, measuring the relationship between the LTV and DTI ratio between households living in the same municipality. The second term is akin to a (weighted) correlation between municipality-level averages of LTV and DTI ratios. This term captures how average LTV and DTI are related across municipalities, adjusting for the size differences between them. The final term is an adjustment factor, to compensate for the fact that the average across municipalities is not the same as the average across households, since municipalities are different in size.

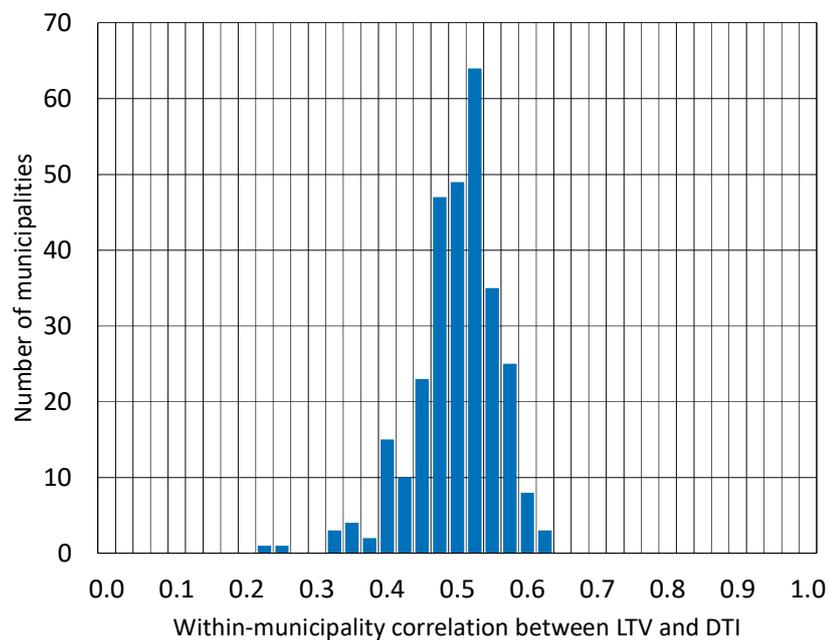
Table A1 shows the correlation between LTV and DTI ratios, as well as its three components, for the years 2010 and 2016. The components have very similar magnitudes in every year of our data. As discussed in the main text, the correlation between municipalities (the second term) is negative, while the correlation between households is positive. The difference stems from the fact that within-municipality correlations (the first term) are positive.

Table A1: Decomposition of the correlation between LTV and DTI ratios

Year	Correlation across households	Correlation within municipalities	Correlation between municipalities	Adjustment factor
2010	0,41	0,45	-0,06	0,02
2016	0,39	0,43	-0,06	0,02

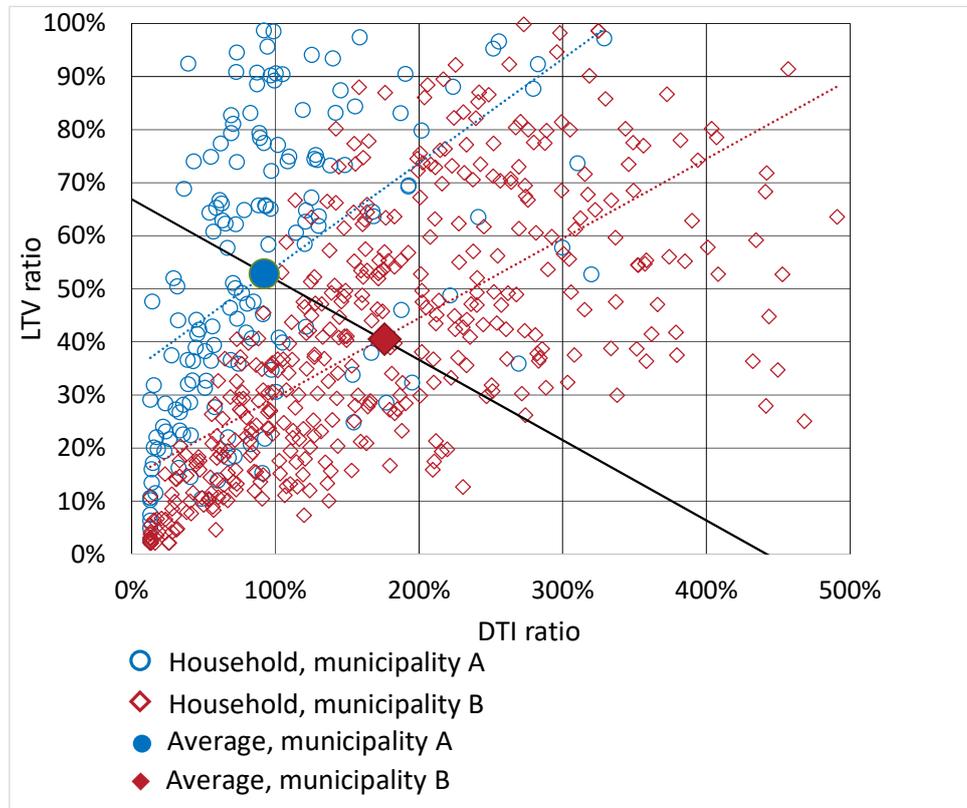
Figures A1 and A2 further illustrate the driving forces behind the positive correlation. Figure A1 shows the distribution of the LTV-DTI correlation, computed separately for each municipality in the year 2016 (i.e. the term $Corr_k(y, x)$). These range between 0.2 and 0.65, with most municipalities having a correlation between 0.45 and 0.55. Figure A2 shows household-level DTI and LTV ratios for two randomly selected municipalities (in blue circles and red diamonds, respectively). The dashed blue and red lines display estimated linear relationships between LTV and DTI, and show that, in both municipalities, these ratios are positively correlated. In contrast, the solid black line, which simply connects the averages by municipality, is downward sloping. This diagram exemplifies that the relationship between averages can be misleading if the data has a group structure.

Figure A1. Correlations between LTV and DTI within municipalities



Note. Data is from July 2016. The figure shows the distribution of the correlation between households' LTV and DTI ratios, computed separately for each municipality.
 Source: The Riksbank.

Figure A2. Correlations between LTV and DTI within municipalities



Note. Data is from July 2016. The figure shows household-level LTV and DTI ratios in two randomly selected municipalities (A and B). The dashed blue line is a least-squares fit for municipality A, and the dashed red line is a least-squares fit for municipality B. The black solid line connects the municipality-level averages of DTI and LTV ratios.
 Source: The Riksbank.