European Commission

ISSN 2443-8030 (online)

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ECONOMIC BRIEF 021 | DECEMBER 2016

EUROPEAN ECONOMY

Economic and Financial Affairs

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Luxembourg: Publications Office of the European Union, 2016

KC-BE-16-021-EN-N (online)
ISBN 978-92-79-54495-8 (online)
doi:10.2765/319544 (online)

KC-BE-16-021-EN-C (print)
ISBN 978-92-79-54494-1 (print)
doi:10.2765/858877 (print)

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Directorate-General for Economic and Financial Affairs

House Prices and Indebtedness in Sweden: a Model-based Assessment of Policy Options

By Matthias Burgert, Patrick D'Souza and Geert Vermeulen

Summary

House prices and mortgage debt in Sweden have grown steeply over the last two decades. This has been driven partly by strong fundamentals but also by the favourable tax treatment of property investment and mortgage borrowing, as well as particular features of the Swedish mortgage market (low amortisation rates and a high share of variable-rate mortgages) that reduce effective debt service costs. The steep rise in household indebtedness creates medium-term risks of a disorderly deleveraging process that could have an adverse impact on the real economy and potentially the banking sector. Accordingly, the Commission (COM(2016) 95 final/2) identified Sweden as experiencing a macroeconomic imbalance deserving monitoring and policy action.

In this Economic Brief, we simulate the macroeconomic impact of three potential policy options that could help to address Sweden's house price/mortgage debt dynamic: (i) a tighter mortgage amortisation requirement; (ii) abolishment of mortgage interest tax deductibility; (iii) higher recurrent property taxes. For the latter two measures, the incremental tax revenues from these policies are allocated to reducing labour taxation, so that the measures are ex ante budget-neutral.

While specific quantitative outcomes of macroeconomic simulations should be interpreted with care, our analysis suggests that a more ambitious mortgage amortisation requirement could significantly reduce household indebtedness, with no meaningful adverse impact on growth, jobs, or long-run housing investment, and that the two tax-related policy options could also help to reduce indebtedness while raising output, consumption and employment. All three policy scenarios have the (desirable) effect of weighing somewhat on long-run house price growth, without causing a ‘hard landing’ or an excessive reduction in long-run housing investment.

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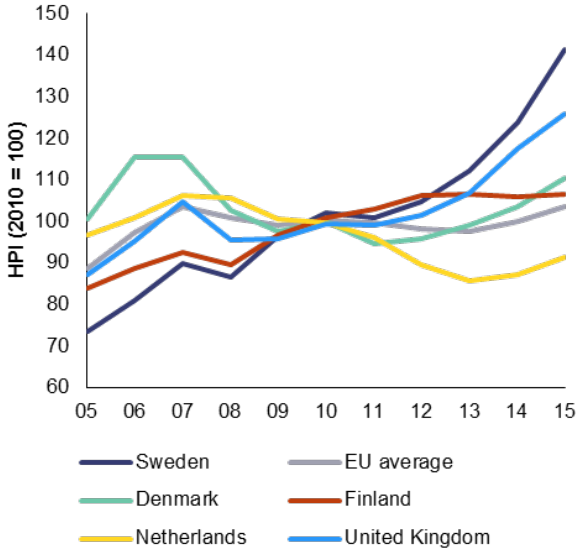
Introduction: house price and household debt developments

Swedish house prices have risen rapidly and persistently over the past two decades. To some extent this reflects a wider dynamic evident in many other economies as well, driven by low interest rates and generally favourable credit conditions. Nevertheless, Sweden stands out for both the vigour and resilience of its property price boom. Indeed, Sweden is one of very few European countries that have experienced strong house price inflation both before and after the global financial crisis, without any significant corrections (Graph 1).

Graph 1: House price index (HPI) for Sweden and selected EU countries (2010 = 100)

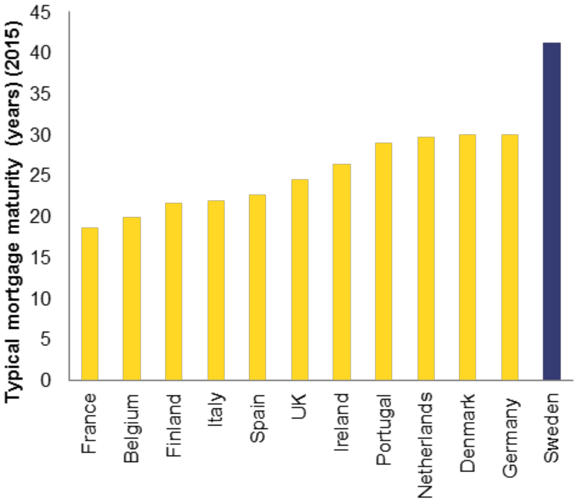


Source: Eurostat

Sweden's high house prices partly reflect strong fundamentals, notably relatively rapid population and income growth coupled with structural underinvestment in new housing and supply side inefficiencies (European Commission, 2016). Taking this into account, prices are still looking increasingly overstretched, with recent estimates pointing to a potential overvaluation of about 20% (European Commission, 2016).

One key factor underpinning Sweden's remarkable house price growth is the structure of its mortgage contracts. Historically, they feature very long maturities (Graph 2) and generally little or no obligation to amortise the loan principal over time. Moreover, mortgages are usually tied to short-term interest rates, with around three out of four households having a fixed interest term of less than one year (Finansinspektionen, 2016). The largely interest-only, variable-rate nature of Swedish mortgages effectively amplifies the financial impact of the historically low short-term interest rates currently in place as it allows households to take higher loans while keeping their monthly payments at the same or even decreasing level.

Graph 2: Typical mortgage maturity (2015)

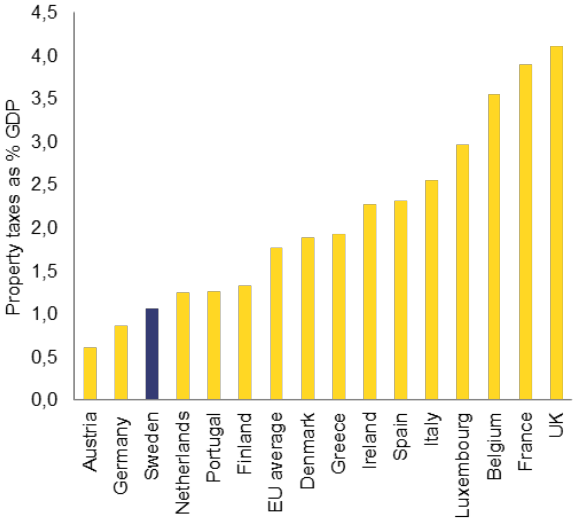


Source: ESRB (based on survey)

Another key contributing factor is Sweden's relatively generous tax treatment of (particularly debt-financed) property ownership, especially since a tax reform in 2008 that capped recurrent property taxes at a relatively low fixed amount. Sweden's tax revenues from property relative to GDP are among the smallest in the EU (Graph 3). Additionally, Sweden is one of just three Member States (together with Denmark and the Netherlands) where mortgage interest payments remain fully tax-deductible. Notably, both the Netherlands and Denmark have recently introduced some reforms to reduce the scope and amount of mortgage interest tax relief (European Commission, 2016).

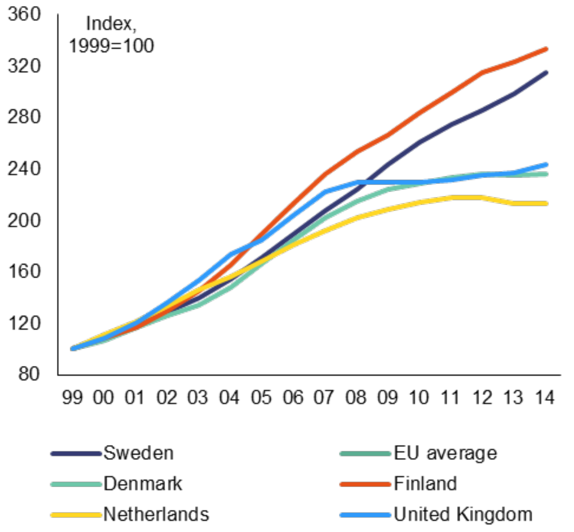
In light of the low cost of mortgage credit and the associated tax advantages, it is not surprising that Sweden's fast-paced property boom has gone hand in hand with a steep rise in mortgage debt. While household debt in most other Member States with a similar housing market / indebtedness dynamic stabilised after the financial crisis, in Sweden it has continued to grow (Graph 4), reaching 179% of disposable income as of end-2015 (Riksbank, 2016).

Graph 3: Property taxes as % of GDP for Sweden (2014) (incl. taxes payable on property transfer)



Source: OECD

Graph 4: Household debt growth (indexed, 1999=100)



Source: European Commission

This dynamic of rapidly rising property prices coupled with high and steadily increasing household leverage makes the Swedish economy vulnerable to shocks (Riksbank, 2016; Finansinspektionen 2016b). If there was a significant rise in mortgage risk premiums – perhaps triggered by a sizeable house price correction, a wider economic slowdown accompanied by an uptick in non-performing loans, or higher funding costs for Swedish banks as market perceptions about their riskiness worsen – this could force households to rapidly reduce their consumption level to meet rising mortgage interest payments. In addition, a direct "wealth effect" associated with a drop in value of housing and financial assets could also be expected to weigh on household consumption (Chen, 2006). The ensuing drop in demand and the broader increase in economic uncertainty could weigh on growth and lead to job losses, further deteriorating households' ability to service their mortgages. The latter can potentially result in a disorderly deleveraging process and credit losses for Swedish banks, triggering further mortgage risk premium increases and thus exacerbating the adverse economic dynamic described here. Empirical evidence from house price cycles in other countries also supports the conclusion that high household indebtedness tends to foreshadow deeper economic downturns and weaker recoveries following a housing market slump (Crowe et al., 2011).

Accordingly, several Swedish and international institutions have identified Sweden's house price and indebtedness developments as an area that could benefit from robust policy action (Finansinspektionen, 2016b; Riksbank, 2016; Finanspolitiska Rådet, 2016; European Commission, 2016; IMF 2015). Potential policy measures should be designed to achieve a gradual realignment of debt and house price levels with economic fundamentals, while avoiding a "hard landing" scenario or otherwise causing a disruptive shock to the economy.

Sweden, partially in response to country-specific recommendations received in the context of the European Semester since 2011, has already taken some policy steps to address its house price / indebtedness dynamic. These include the introduction of a loan-to-value (LTV) ceiling of 85% for mortgages in 2010, the gradual raising of banks' risk weight floors for mortgages in 2013 and 2014, and an amortisation requirement for new mortgages until the LTV reaches 50%[1], which came into force in June 2016. While the precise effect of these measures is in some cases hard to assess (particularly for the new amortisation rule, which came into force only recently), it does seem that they have had relatively limited impact so far, with Swedish house prices and household indebtedness continuing their relentless rise.

Model-based assessment of potential policy measures

Introduction

For the model-based assessment of the policy measures we use the European Commission's QUEST model.[2] QUEST is a global macroeconomic model developed for policy analysis and research. The model used in this paper consists of three regions: Sweden, the euro area and the rest of the world. All three regions are calibrated to match essential properties of national accounts data and bilateral trade linkages between the regions.

In each region, the model distinguishes between two types of households that both own houses, but finance their property acquisition differently. The first type, referred to as "financially unconstrained" households or simply as "outright homeowners", do not require a mortgage to purchase their home[3]. The second type are the "credit-constrained" or "mortgaged" households, who can finance their housing stock only by taking up a mortgage. The model allows simulation of a scenario in which both types of households pay a recurrent property tax, levied at a flat rate on the housing stock. The tax deductibility of mortgage interest payments is modelled as a government subsidy to mortgaged households to their mortgage interest rate.[4]

We model the following potential policy reforms, which broadly correspond to recommendations Sweden received as part of EU macroeconomic surveillance procedures (European Commission, 2016): (i) a tighter mortgage amortisation requirement (relative to the amortisation rule put in place in June 2016, as described above), (ii) a reform of mortgage interest tax relief (with the tax savings used to lower labour taxes) and (iii) a direct tax shift from labour to recurrent property taxes. The tighter mortgage amortisation scenario increases the adjustment speed in mortgage debt holdings of credit-constrained households, resulting in a reduction of their aggregate loan-to-value ratio. In the mortgage interest tax relief reform scenario, we assume full abolition of the government subsidy to mortgage debt. Ex ante the government neutralises this financially by lowering the tax on personal income – an assumption we make to optimise the broader economic impact of this tax reform, as labour taxes in particular have been identified as among the most distortive types of taxation (European Commission, 2014). Similarly, in the tax shift scenario, the government shifts revenue from personal income taxes to the recurrent property tax on housing. Both fiscal reforms are ex-ante budget neutral. Ex-post, the government budget balance can deviate from its target (at which the debt-to-GDP ratio is stabilised in the short to medium run) owing to second round effects of the reforms on tax bases. In the long run, the personal income tax rate is adjusted to stabilise the debt ratio.[5]

The general equilibrium nature of the QUEST model allows us to focus on a multitude of macroeconomic variables in these reform scenarios. We are particularly interested in the evolution of house prices, household debt, employment, consumption and GDP. While we do not undertake a welfare analysis, distributional questions within the context of this Economic Brief can be addressed through the relative evolution of the housing stock and consumption levels of the two types of households.[6]

Specific quantitative outcomes of our analysis should be interpreted with care. Macroeconomic simulations inevitably require certain stylised assumptions to be made and by definition abstract from sentiment effects that may result from the introduction of significant reforms. More generally, we assume that households are rational economic agents planning their consumption and investment decisions over a long time horizon; in reality, some households may exhibit "myopic" planning behaviour, which could amplify the impact of policy changes in certain scenario (Berg and Hansen, 2014). It is therefore important to emphasise that the purpose of these simulations is primarily to further our understanding of the underlying dynamics through which the various policy scenarios affect the housing market, household debt and the broader economy. Related to this, and taking into account quantitative estimates from a range of other studies as well, we also aim to get a general indication of the relative impact of the different policy options and their respective benefits and drawbacks.

Tighter mortgage amortisation

Graph 5 shows the simulated impact of the tighter mortgage amortisation policy scenario on key economic and housing market indicators. The reform is designed to yield a 10% reduction in the mortgage-debt-to-GDP ratio in the long run. We find that this requires an incremental increase in the average amortisation rate corresponding to 0.6% of outstanding mortgage debt per year[7].

As a consequence of larger mortgage repayments households with a mortgage will spend somewhat less on acquiring a property: their level of housing investment drops by 3.5-4% relative to the baseline in the short and medium-run. This drop in demand marginally weighs on house prices, which raises the attractiveness of housing as an investment for financially unconstrained households. As a result, these households will modestly increase their level of housing investment, thus partly offsetting the drop in housing demand from credit-constrained households.

The higher mortgage repayments for mortgaged households also reduce their consumption level. Within the model the resulting drop in aggregate demand is triggering a somewhat softer monetary policy stance (relative to the baseline). On the margin, this stimulates outright homeowners to consume more, thus cushioning the overall consumption fall. The aggregate impact on consumption is therefore minor and – thanks in part to the reduction in household debt (and thus mortgage payments) gradually resulting from the faster amortisation rate – in the long-rung even positive. Another important contribution for the latter stems from the fact that aggregate consumption is stimulated further by a reduction in personal income taxes in the long-run. This reduction compensates in the government budget for the lower subsidies paid to households on mortgage interest. It is one important reason for GDP and employment effects being positive in the long run as well.

From a distributional point of view this reform gives a mixed picture: during the deleveraging process the reform is regressive (both in terms of housing stock and consumption levels), however, it is progressive in the long run.

Finally, the enhanced amortisation rate leads mortgage debt to gradually shrink compared to the baseline level, resulting (by design) in a long-run reduction in household debt of 10% of GDP.

In short, the simulations suggest that a more ambitious mortgage amortisation requirement could lead to a meaningful long-run debt reduction at a limited cost in terms of output, consumption and employment – and without causing a "hard landing" in house prices or depressing long-run growth of the housing stock.

Mortgage interest tax relief reform

Graph 6 shows the simulated impact of a permanent abolishment of mortgage interest tax deductibility, with the resulting tax savings (amounting to about 0.6% of GDP) used to reduce personal income taxes.

Since mortgage interest tax relief effectively acts as a subsidy to mortgage rates, the elimination of this tax deduction significantly increases the financing costs for housing investment by credit-constrained households. As an immediate reaction, they reduce the level of housing investment by about 6%, which gradually tapers off over time. Similar to the previous policy scenario, this has a modest negative impact on property prices, thus attracting increased investment from financially unconstrained households into the housing market.

Over time, this shifting housing investment pattern results in a gradual redistribution of a small part of the housing stock from mortgaged households (whose housing stock ownership declines by 2%) to outright home-owning households (whose housing stock increases by 1.2%). There is virtually no long-term net effect on the size of the aggregate housing stock.

Since the tax revenues from the mortgage interest relief removal are fully used to reduce labour taxes, the financial impact of losing the subsidy for credit-constrained households is partially offset by higher after-tax employment income. Still, the net effect for this group is an initial drop in consumption spending of up to 1.7% relative to the baseline, softening to about 1.5% in the long-run. For the outright home-owners, the labour tax reduction leads to a gain in income and consumption. In aggregate, household consumption picks up gradually. Thanks to the growth-friendly impact of reducing the labour tax wedge, in the long run this reform has a modest positive effect on GDP, consumption and employment.

The distributional implications of this reform appear regressive with respect to consumption and the housing stock. However, this is linked to the modelling assumption that financially unconstrained households never incur any mortgage debt, whereas in reality relatively wealthy Swedish households often do have mortgages (for instance for tax planning purposes). A microanalytical approach does indeed lead to the conclusion that in practice this reform would have a progressive distributional impact (Englund, 2016).

As can be expected of a policy option that removes a subsidy on mortgage borrowing, long-run household indebtedness is projected to drop relative to the baseline scenario (by 1.3% of GDP).

Recurrent property tax reform

Graph 7 shows the simulated impact of the recurrent property tax policy scenario. The reform is designed to shift government revenue from labour taxes into recurrent property taxes by about 0.6% of GDP (i.e., calibrated to the same effective size as the mortgage interest deductibility reform discussed above). This is estimated to amount to an average increase[8] in annual property taxes of about 0.3% of residential property values.

Since an uncapped recurrent property tax makes owning housing wealth comparatively less attractive, the tax shift will lead households to significantly reduce their level of housing investment. This lowers house prices by 2-2.5% compared to the baseline. The drop in house prices makes the acquisition of housing cheaper for households needing a mortgage. Accordingly, these households respond to the drop in prices – also helped by higher employment incomes resulting from lower labour taxes – by investing somewhat more in housing compared to the base case. This partially offsets the lower investment from financially unconstrained households. In aggregate, the reduction in housing investment amounts to 1.5-2.9% in the short to medium-run, gradually levelling off to 1.8% over longer time horizons.

The growth-friendly effect of the reduced labour tax wedge helps raise incomes, allowing households to increase their consumption level. In the short and medium-run, this effect is minor for households needing a mortgage, because they allocate most of their income gain to increased housing investment. However, over the longer run, both types of households benefit from increased consumption of about 0.4%. The reduction in labour taxes also results in a small boost to GDP and employment.

Consequently, the reform has favourable distributional implications in the long run. While both consumption levels grow at the same rate, the housing stock of constrained households is increasing while that of unconstrained households is decreasing. Intuitively, this reform is a redistribution of the tax burden from labour to home ownership. Given that in our model outright home owners possess a larger housing stock on average than mortgaged households, they are also much more affected by the increase in the recurrent property taxes. At the same time the personal income tax reduction affects all households to the same extent.

Unlike the two other policy scenario, the tax shift option does not directly target mortgage debt. However, the resulting reduction in house prices, combined with slightly higher output, does help reduce household indebtedness as a percentage of GDP by about 0.8%.

Comparison and possible policy implications

Table 1 compares the medium and long-term impact of the three simulated policy scenarios.

Although all three policy options ultimately contribute to lowering household debt, the quickest and largest impact can be achieved by mechanically forcing a gradual reduction via a more ambitious amortisation requirement. The simulations suggest this can be done with little or no adverse long-run impact on growth, house prices and the overall size of the housing stock.

The main benefit of the tax-related policy options on the other hand is their growth-friendly nature, translating into improved prospects for output, employment and consumption. In both cases the long-run impact is projected to be fairly modest but still significant: as an example, for both measures the long-run employment increase is equivalent to about 10 000 new jobs created (an increase of roughly 0.2% in the employment rate). In the recurrent property tax policy option, these gains are projected to materialise more quickly than in the case of mortgage interest relief removal, where household consumption is only increasing gradually. In addition, the recurrent property tax reform scenario makes a bigger contribution to stemming house price growth (but still without causing a "hard landing"). On the other hand, it has the disadvantage that it reduces housing investment, and therefore the size of the housing stock, somewhat in the long run. In contrast, the abolition of mortgage interest relief merely leads to a small redistribution between the different types of home-owners, without a significant overall impact on the housing stock.

Overall, the simulations offer support for the more general theme that an appropriate mix of macroprudential policies and targeted property taxation reforms can assist in keeping house price and indebtedness developments in check in a growth- and employment-friendly manner. Several other EU member states with similar house price and mortgage debt dynamics as Sweden have indeed implemented this type of reforms in recent years (European Commission, 2016). As noted above, Sweden itself has also taken steps in this general direction (loan-to-value ceiling; limited mandatory amortisation for new mortgages). Our analysis suggests that a more ambitious amortisation requirement combined[9] with reforms to mortgage tax treatment and/or property taxation are worthwhile further policy options to consider. However, to resolve Sweden's broader housing market issues, such demand-side measures would need to be complemented by a wider-reaching policy package that addresses bottlenecks for new construction and efficient usage of the existing housing stock as well (European Commission. 2016).

Our results are broadly in line with previous studies (Table 2), which generally also point towards the overall conclusion that macroprudential policies can achieve comparatively large effects on indebtedness with little or no macroeconomic cost[10]. In addition to the macroeconomic impact of recurrent property taxes and mortgage interest deductibility reforms, the redistributive effect of these policies across income deciles has been studied as well: Englund (2016), using a microsimulation model, finds that the income impact for most individual households is modest and that the overall outcome is broadly progressive.

In terms of modelling technique our approach compares best to Finocchiaro et al. (2016). Both the QUEST model and the model Finocchiaro et al. use feature the same split between two types of households, home owners and mortgaged households, which both finance their property acquisition differently. Furthermore, both models are calibrated based on the same evidence. However, major differences remain, namely the assumptions made on the supply of housing services and our assumption that the government uses its additional budgetary room (from lower subsidies to mortgage debt) to lower personal income taxes.[11] This to some extent explains the discrepancy in size of the effects of reforms on house prices and consequently the mortgage-debt-to-GDP ratio.

Conclusion

We consider three potential macroprudential and taxation-related policy options to address the rapid growth of house prices and indebtedness in Sweden and simulate their macroeconomic impact using the European Commission's QUEST model.

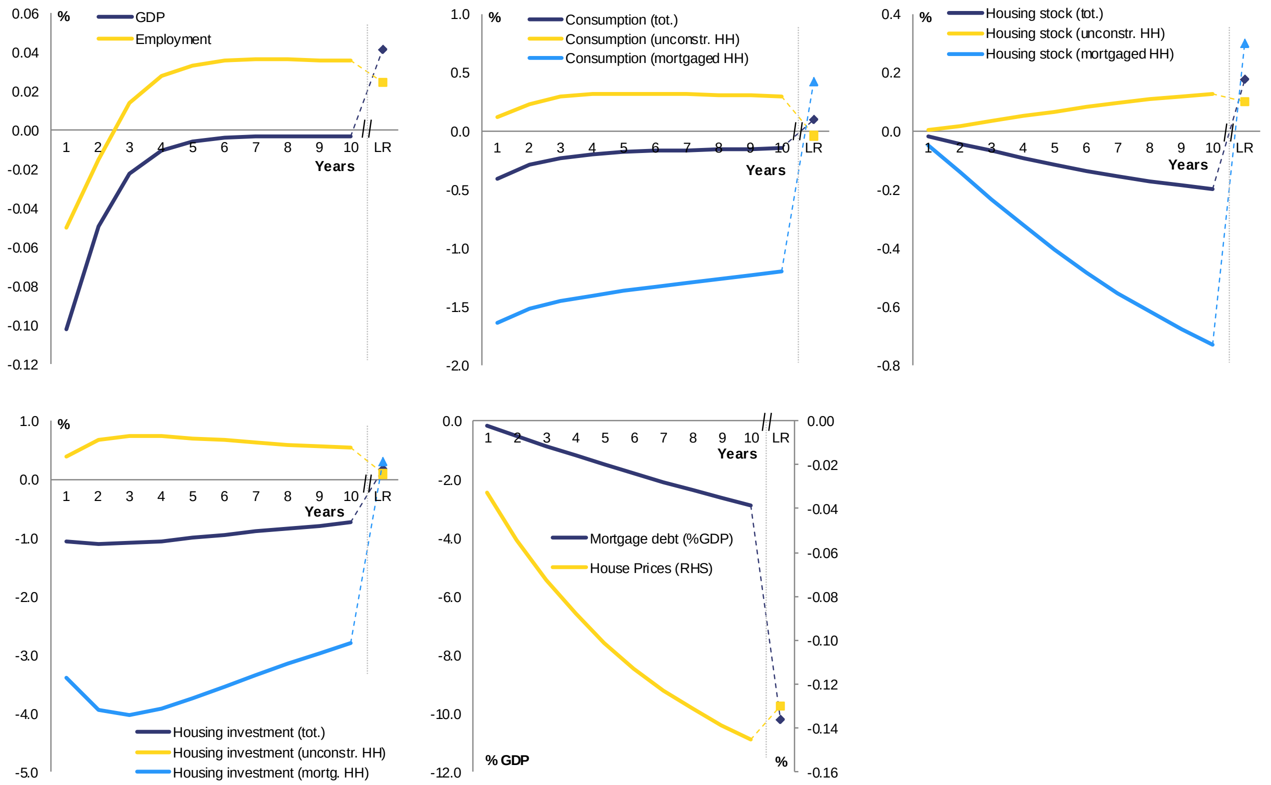
We show that a more ambitious mortgage amortisation requirement could significantly reduce household indebtedness, with no meaningful adverse impact on growth, jobs and long-run housing investment.

Reforms to the taxation of housing assets – specifically, abolition of mortgage interest tax deductibility or introduction of meaningful recurrent property taxes – can also help reduce indebtedness. However, the main benefit of these policies is that the additional tax revenues created can be used to reduce labour taxes, which raises long-run output, consumption and employment. While care must be taken in interpreting specific quantitative results from any macroeconomic modelling exercise, our simulations suggest that these tax reforms could boost consumption by a 0.3-0.4% and create around 10 000 new jobs over time. From a distributional point of view the reform that shifts the tax burden from labour to housing wealth is most beneficial.

Notably, although all three policy scenarios have the (desirable) effect of weighing somewhat on long-run house price growth, our simulations show that they do not lead to any "hard landing". Similarly, none of these policy options results in an excessive reduction in long-run housing investment (although there is a modest drop in the case of recurrent property taxes).

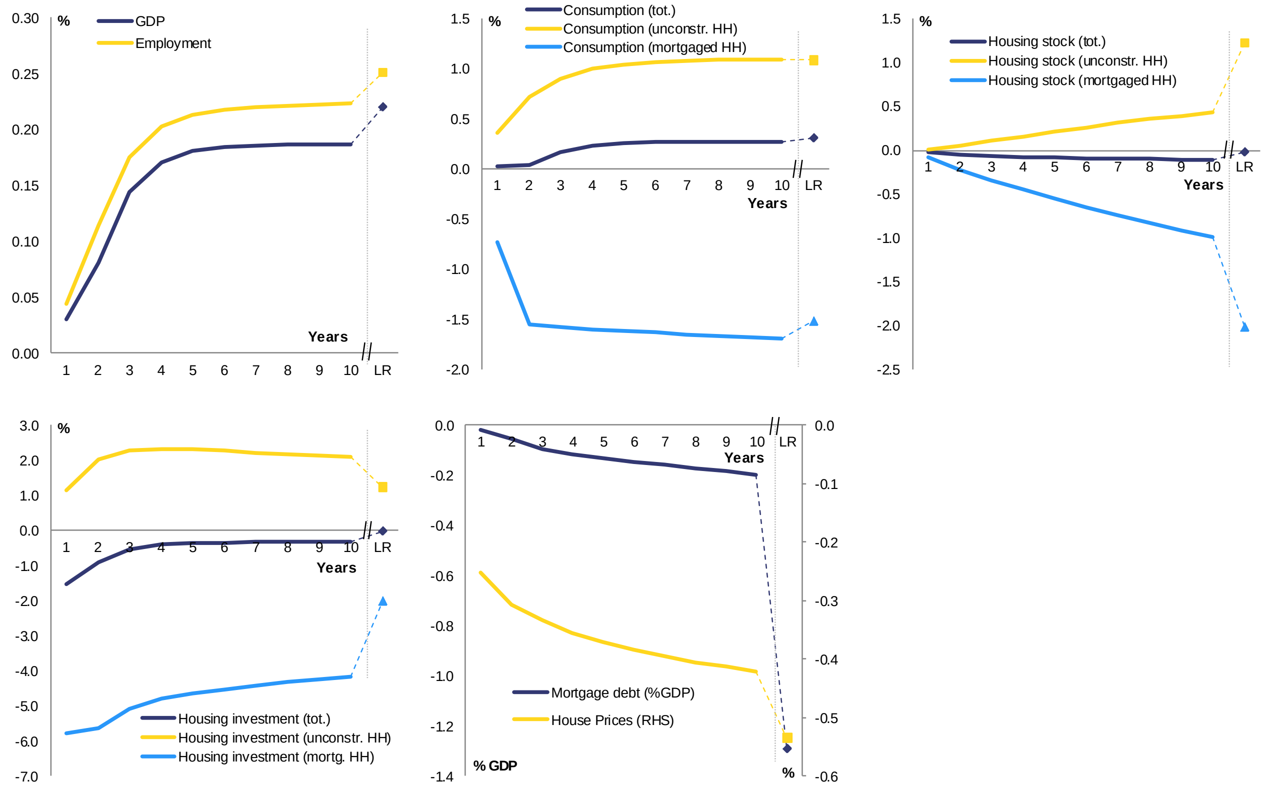
In conclusion, we find that a more ambitious mortgage amortisation requirement and/or targeted mortgage tax deductibility and property taxation reforms can help restrain Sweden's house price and indebtedness dynamic in a growth-and employment-friendly manner.

Chart 5: **Tighter amortisation requirement policy option: simulated impact vs. baseline (years 1-10 and long-run)**



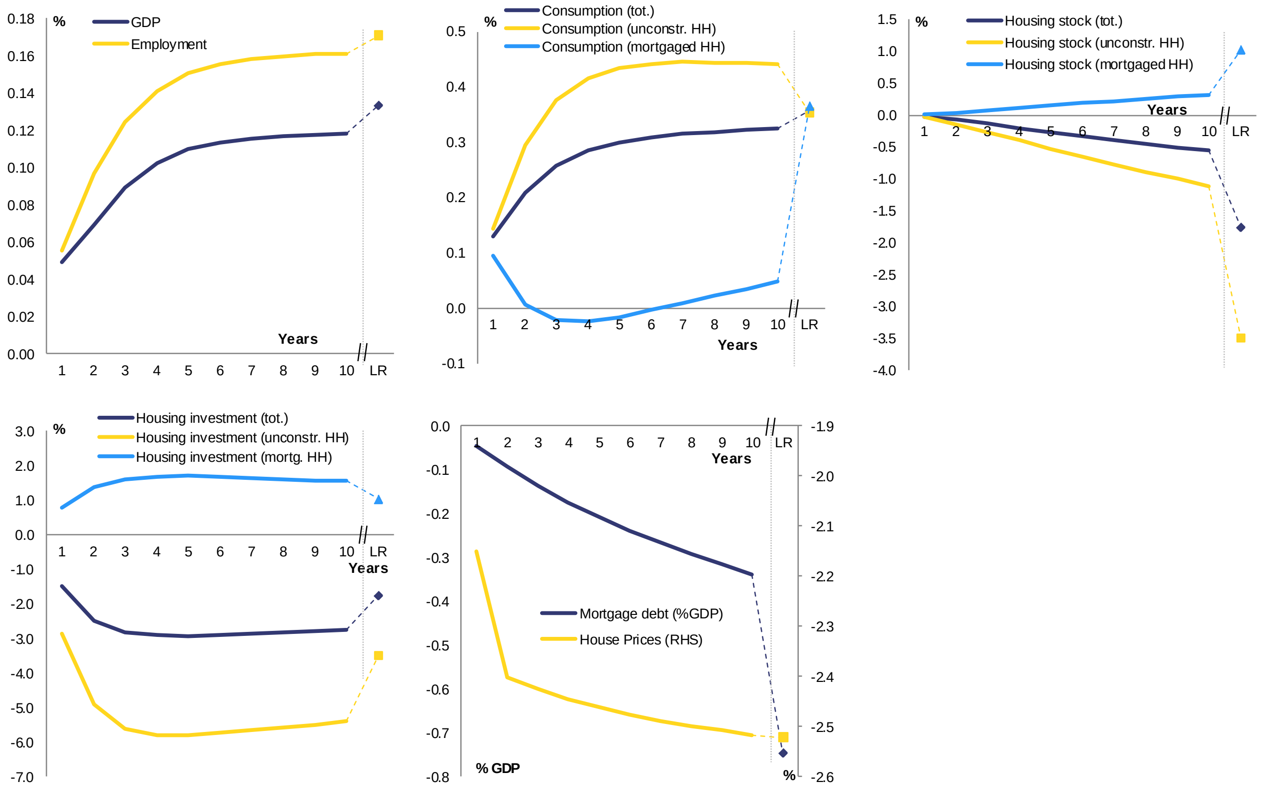
Source: Commission analysis

Chart 6: **Mortgage interest tax deductibility abolition policy option: simulated impact vs. baseline (years 1-10 and long-run)**



Source: Commission analysis

Chart 7: **Recurrent property tax reform policy option: simulated impact vs. baseline (years 1-10 and long-run)**



Source: Commission analysis

Table 1: **Medium- and long-run impact of simulated policy scenarios**

		Tighter amortisation requirement	Mortgage tax relief abolition	Recurrent property tax
Medium-term impact (5 years)	GDP[1]	0.0	0.2	0.1
	Employment[1]	0.0	0.2	0.2
	Consumption[1]	-0.2	0.2	0.3
	House prices[1]	-0.1	-0.4	-2.5
	Housing stock[1]	-0.1	-0.1	-0.3
	Household debt / GDP[2]	-1.5	-0.1	-0.2
Long-run impact[3]	GDP[1]	0.0	0.2	0.1
	Employment[1]	0.0	0.2	0.2
	Consumption[1]	0.1	0.3	0.4
	House prices[1]	-0.1	-0.5	-2.5
	Housing stock[1]	0.2	0.0	-1.8
	Household debt / GDP[2]	-10.2	-1.2	-0.8

Notes:
1) GDP, employment, consumption, house prices and housing stock: impact expressed as percentage of base-case level.
2) Household debt / GDP: impact expressed in percentage points
3) See endnote 5 for further background on the meaning of "long-run" in our macroeconomic modelling framework.

Source: Commission analysis

Table 2: Comparison with other studies

Study	Modelling approach	Relevant policy scenarios analysed	Long-run impact on…		
			Debt / GDP	**GDP**	**House prices**
Chen, J. and Columba, F. (2016)	DSGE model	Lower loan-to-value (LTV) ceiling (from 85% to 80% for new loans)	-10%	-0.5%	-1.5%
		Tighter amortisation requirement (from 50 to 45 years)	-10%	-0.4%	-0.5%
		Mortgage interest deductibility (MID) reduced (from 30% to 25%)	-2.2%	+0.1%	
Finocchiaro, D. et al. (2016)	DSGE model	Lower LTV ceiling (from 75% to 69.5% for new loans)	-10%	-0.4%	-1.6%
		Tighter amortisation requirement (from 50 years to 45 years)	-10%	-0.3%	-0.4%
		MID largely eliminated (from 30% to 6.2%)	-10%	+0.3%	-3.6%
		Loan-to-disposable-income (LTI) ceiling (drop from 483% to 426% of disposable income)	-10%	-0.3%	0%
Riksbank (2014)	Two DSGE models and in-house Riksbank forecasting model[1]	Tighter amortisation requirement (from average of 56 years to 35 years)	-31%	-0.1%	-0.2 to -0.9%
		Tighter amortisation requirement (LTV-based[2])	-13%	-0.1%	-0.3%
European Commission (2014)	DSGE model (QUEST) for generic case (not calibrated to Sweden)	Tax shift: recurrent property taxes (1% of GDP) used to reduce wage tax wedge		0%	-3%
		MID eliminated		0%	-0.2%
Hull (2015)	Life-cycle model	Tighter amortisation requirement (LTV-based[2])	-1.2 to -2.8%		
Svensson (2016)	Life-cycle model	Tighter amortisation requirement (2% / year, versus no amortisation at all)	+4 to +7%		

Notes:

1) Results shown are average for three models

2) These studies refer to the LTV-based amortisation requirement that was ultimately implemented in July 2016, but that was still under consideration at the time of publication (see end note 1 for details). The impact estimates from these studies should be interpreted versus a baseline reflecting the typical mortgage structure at the time, with amortisation normally purely voluntary for most lower-LTV loans, whereas most mortgage contracts for high-LTV loans provided for initial amortisation rates of 1-3% per annum until the LTV drops below a pre-specified threshold (typically 70%). Hull (2015) assumes as a baseline an initial amortisation rate of 1% per annum for high-LTV loans, whereas Svensson (2016) uses completely voluntary amortisation as a benchmark scenario.

3) The above studies differ in their modelling strategy. The sometimes fundamentally different approach can explain to some extent the heterogeneity in results. Endnotes 10 and 11 provide a brief explanation of model specificities for the models used by Hull (2015), Svensson (2016) and Finocchiaro et al. (2016).

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[1] Specifically, the new mortgage amortisation requirement imposes a minimum amortisation rate of 2% per annum for newly agreed mortgages with an LTV above 70%, which drops to 1% per annum for mortgages with an LTV below 70% but above 50%. Once a mortgage has been paid down to an LTV below 50%, no further amortisation is required.

[2] More information on QUEST-based analysis can be found here:
http://ec.europa.eu/economy_finance/research/macroeconomic_models_en.htm.
For an estimated version of the model see Ratto, M., Roeger, W., and in 't Veld, J. (2009).

[3] In more technical terms, these are the so-called "Ricardian households", who are financially unconstrained and fully able to intertemporally optimize their consumption and housing investment.

[4] We calibrate the QUEST model to the mortgage-debt-to-GDP ratio of the Swedish economy. Respecting this makes the modelling results less sensitive to a change in the split between mortgaged households and outright home-owners. Intuitively, an increase in the baseline in the share of mortgaged households requires a reduction in the individual households' mortgage debt level to assure the same aggregate mortgage-debt-to-GDP ratio. The individual mortgaged household subsequently reacts less strongly to debt sensitive reforms as it is exposed to less debt. This counterbalances the increased share of mortgaged households at the aggregate level.

[5] With "long run" we are labelling any time horizon beyond which price and wage adjustment in the model in response to a shock is concluded. We label the period during which the adjustment in model variables in response to a shock is taking place as "short" or "medium run".

[6] From a wealth perspective, financially unconstrained households can be considered richer than mortgaged households for several reasons: First, unconstrained households' average housing stock is higher than that of constrained households. Second, unconstrained households own additional capital which they invest into firms thereby generating interest and dividend revenue. Third, unconstrained households are the ultimate lenders of mortgage capital in the model economy.

[7] In the model, for technical reasons we make the assumption that the revised mortgage amortisation rate applies to both new and existing mortgages. In practice, it may be more straightforward to introduce a higher amortisation rate only for new mortgages. However, the long-run impact would be the same in both scenarios in any case, as over time "new" mortgages will come to represent a gradually growing share (and ultimately 100%) of the total mortgage stock.

[8] Sweden currently has a type of recurrent property tax already (the "local property fee" or *kommunal fastighetsavgift*). The nominal tax rate is 0.75% of assessed value for most houses and 0.3% for most apartments, but the tax is capped at a relatively low level (as of 2016, SEK 7 412 and SEK 1 268 per annum for houses and apartments respectively). In practice, therefore, most owners pay a flat fee that does not scale up with the value of their property. There are also various exemptions in place, e.g. for new-build properties, where no local property fee is charged.

[9] When the different simulated policy options are implemented in combination as part of a comprehensive policy package, in our model their respective impact on the relevant macroeconomic variables scales roughly linearly and can be summed up to obtain the estimated aggregate impact for the policy package as a whole.

[10] Specifically for mortgage amortisation policy options, Svensson (2016) and Hull (2015) arrive at the opposite conclusion and find that tighter amortisation requirements would lead to only a small drop or even an increase in indebtedness. However, we believe that these studies do not fully reflect real-world constraints faced by mortgaged households (such as LTV limits) and make assumptions regarding borrower behaviour that are unlikely to materialise in practice (e.g., that households would seek to artificially increase their initial borrowing level above what is needed for their house purchase).

[11] Finocchiaro et al. (2016) assume a fixed supply in housing services resulting in a strong sensitivity of house prices to reforms in equilibrium. In the QUEST model the supply of housing is not fixed, but housing services are produced by a residential construction firm that transforms a combination of land and domestic non-tradable goods into new houses. Firms in the residential construction sector are monopolistically competitive and face price adjustment costs. Furthermore, the residential construction firm's decisions are influenced by the prices for its input factors.

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KC-BE-16-021-EN-N

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ISBN 978-92-79-54495-8