Simulating the impact of borrower-based macroprudential policies on mortgages and the real estate sector in Austria – evidence from the Household Finance and Consumption Survey 2014

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In this paper we simulate the impact on house prices and credit available of different macroprudential restrictions on household mortgages in Austria. We apply the methodology developed in the literature for credit register-based information and extend it to the use of survey data. This allows us to make use of the data gleaned from the most recent wave of the Household Finance and Consumption Survey (HFCS) in Austria to investigate the linkages between macroprudential policy and credit supply. We find that of the three standard credit ratio-based criteria – loan to value (LTV), debt to income (DTI) and debt service to income (DSTI) – for most households, the income-based criteria (DTI followed by DSTI) are the binding ones, while the role of LTV is limited. The relationship between credit supply and house prices is found to be positive, but weak. We simulate various macroprudential scenarios and find that macroprudential measures may potentially have sizeable effects on the credit available to households for financing real estate. Furthermore, it can be seen that – as expected – macroprudential policy tends to affect less affluent mortgage holders (although at the median, mortgage holders are more affluent than the general household population). The results also show that the simulated macroprudential policy measures trigger smaller changes of house prices.

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The aggregate stock of housing loans in Austria trended upward over the whole period from 2006 to 2015 (see chart 1). Even after the onset of the financial crisis in 2008, housing credit growth has been quite robust, supported by historically low interest rates and the ongoing dynamics in the housing market.

However, the interrelationship between housing loans and house prices seems to be not very strong in Austria. For instance, the surge in house prices during 2012 does not seem to have been driven by increases in the housing debt stock. Possible reasons for the apparently weak interrelationship between housing loans and house prices in Austria could be the dominant role of subsidized low-rent apartments, the fact that family homes are commonly kept for a very long period and therefore are a form of very long-term investment, or the role of inheritances.

Nevertheless, chart 1 clearly shows an increase in real estate prices and also an increase in household mortgage debt levels. In fact, the strongest increase in residential property prices of the whole euro area was measured in Austria between 2007 and 2016. According to the indices available in the ECB Statistical Data Warehouse, nominal prices rose by 60% between the first quarter of 2007 and the third quarter of 2016,

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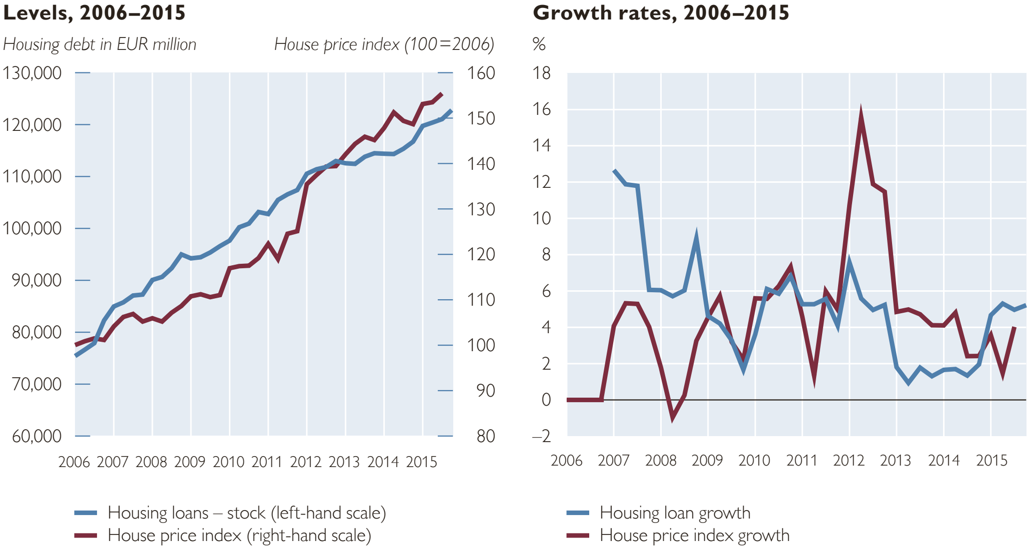
Chart 1

Housing debt and house prices in Austria



Source: OeNB.

while they stagnated in the rest of the euro area. Albacete et al. (2016a) find that strong increases in available house price indices in Austria are likely to be driven by the upper part of the house price distribution. Although a number of studies have put forward reasons arguing that the mortgage debt of households in Austria is sustainable (see e.g. the analyses in Albacete and Fessler, 2010; Albacete et al. 2012; Beer and Wagner, 2012; Albacete and Lindner, 2013; Albacete et al., 2014; Albacete and Lindner, 2015; and others[2]), in October 2016 the European Systemic Risk Board (ESRB) issued an official warning concerning vulnerabilities in the Austrian real estate sector.[3] Following a discussion of real estate developments and debt sustainability, the Financial Market Stability Board (FMSB) in Austria issued a statement particularly focusing on vulnerability indicators of households in Austria.[4]

So far all the analyses about the household mortgage market and vulnerability in Austria have focused on the identification of potential weaknesses of the sector (e.g. stress testing or examining the role of foreign currency loans to households). However, in light of the FMSB's official statement, an assessment of the potential impact of macroprudential policy measures on households and the real estate market seems warranted. Macroprudential policy is complementary to monetary policy and can play an important role in limiting the build-up of risks, e.g. in a situation of strong debt-driven house price increases, as, for instance, the Irish experience has shown.[5]

[2] *For some more references see also https://www.oenb.at/en/Monetary-Policy/real-estate-market-analysis/publications.html.*

[3] *http://www.esrb.europa.eu/mppa/warnings/html/index.en.html.*

[4] *https://www.fmsg.at/en/publications/press-releases/2016/tenth-meeting.html.*

[5] *http://www.centralbank.ie/stability/MacroprudentialPol/Pages/LoantoValueLoantoIncome.aspx.*

Furthermore, macroprudential policies also aim to limit contagion effects in the financial sector and to create the right set of incentives for market participants.[6]

Until now there has been a lack of information on the potential impact of macroprudential policy measures. However, since understanding the role macroprudential policy could play in limiting the build-up of risks is essential, this study intends to shed some light on this topic. As recommended by the ESRB handbook (ESRB, 2014), the paper takes the borrowers' perspective. We perform an impact analysis of macroprudential intervention in Austria, setting constraints to the loan-to-value (LTV), the debt-to-income (DTI) and the debt service-to-income (DSTI) ratios, with a focus on measuring the effects of such interventions on the real estate sector, i.e. mortgage supply and house prices. We adapt the approach developed by Kelly et al. (2015) and use the best and most recent source of information available, i.e. data from the second wave of the Household Finance and Consumption Survey (HFCS 2014) for Austria. The methodology applied in this study basically consists of four main steps: identifying market conditions, estimating the maximum credit available to consumers, running house price regressions and simulating various macroprudential scenarios. We find a potentially sizeable impact on credit available whereas the impact on house prices is smaller. Additionally, we are able to identify and discuss the group characteristics of affected households.

The study is structured as follows: Section 1 details the methodology applied; section 2 introduces the survey data; and section 3 presents and discusses the results step by step to ensure maximum transparency in the simulation. Within this section, subsections 3.3 and 3.4 in particular lay out and discuss the simulation results and the information obtained about the affected group of households. Section 4 concludes and points toward potential extensions.

1 Estimation strategy

We make use of the methodology proposed by Robert Kelly, Fergal McCann and Conor O'Toole (Kelly et al., 2015) from the Central Bank of Ireland. It basically consists of four main steps, which are discussed in detail below. It has to be stressed that due to data differences (see section 2), our approach is not completely identical to Kelly et al. (2015), but we tried to follow the proposed methodology as closely as possible.

1.1 Determination of the maximum LTV, DTI and DSTI allowed by banks for each period

As a first step we identify the prevailing market conditions in Austria. We infer these credit market conditions by studying the distribution of ratios on credit standards at the time of the origination of a mortgage. We consider three ratios: the loan-to-value (LTV), the debt-to-income (DTI) and the debt service-to-income (DSTI) ratios.

Considering the distribution of these debt burden ratios, it seems obvious that the prevailing market conditions with respect to the most extreme values that are financed by the banking sector are given by relatively high percentiles. Although we do not directly consider the maximum observed value, for the sake of simplicity we refer to

[6] *https://www.ecb.europa.eu/ecb/tasks/stability/html/index.en.html.*

these parameters as maximum DTI (DTI_{Max}), maximum LTV (LTV_{Max}), or maximum DSTI ($DSTI_{Max}$) in the remainder of the paper.

1.2 Computation of available credit (i.e. maximum credit amount satisfying the credit standard constraints) at the borrower level

Having identified the prevailing market conditions for the maximum ratios banks are willing to provide,[7] it is possible to calculate the amount of credit each individual household might obtain along each channel, i.e. LTV, DTI, DSTI, based on some relevant characteristics of each household (e.g. wealth and income levels).

We can thus compute the maximum credit amount satisfying these constraints for each borrower household denoted *i*. Calculating the down payment available to the borrower and denoting it $deposit_i$, we calculate the maximum credit along the LTV channel[8] for a borrower by

$$Loan_{LTV_i} = \frac{deposit_i}{1 - LTV_{Max}} - deposit_i.$$

Based on (initial) income we can calculate the maximum credit along the DTI channel by

$$Loan_{DTI_i} = income_i \times DTI_{Max}.$$

The last channel is a bit more complicated since we need to specify the term of the loan in the market, denoted by *TERM*, as well as the interest rate. Based on a household's income and the prevailing conditions ($DSTI_{Max}$) a maximum repayment per year can be defined, denoted $RepayMax_i$, which can be used, together with the compound interest formula, to calculate the maximum credit available along this channel by

$$Loan_{DSTI_i} = RepayMax_i \times \frac{1-(1+r_i)^{-TERM}}{r_i},$$

$$\text{with } RepayMax_i = income_i \times DSTI_{Max}.$$

The concrete specifications chosen for the above formulas are explained in section 2. Obviously, a bank will consider all three channels together as well as additional information available about the mortgage taker. Here we provide the channels one by one in order to be clear and transparent. Thus, putting all the channels together and taking the minimum, we are able to estimate the credit available for each household. It is calculated as follows:

$$Credit\ Available_i = Min(Loan_{LTV_i}, Loan_{DTI_i}, Loan_{DSTI_i})$$

The measure of available credit represents the amount of funds the bank (the market) is willing to supply to a household after considering the three credit ratio criteria together. Importantly, it is not the amount of credit really given to the household. There might be many reasons why a household may be able to purchase the desired property without taking out the entire available credit, e.g. the availability of sufficient funds from other sources.

[7] *Although it is acknowledged that a relationship between a costumer/household and a bank or other aspects might influence the maximum credit available to an individual household, we take the prevailing market condition derived above as a first best approximation of the maximum credit ratio a household is able to obtain from a bank.*

[8] *This equality is obtained by definition, expressing LTV as the ratio of loan to price and price as the sum of loan and deposit. Note that $Loan_{LTV_i}$ is not defined for LTV_{Max}=100%. The intuition is that in such cases banks offer unlimited or "infinite" financing of properties through the LTV channel.*

1.3 Estimation of the response of housing prices to the amount of available credit

Once we have computed the amount of credit available at the level of each borrower, we can estimate the relationship between house prices and available credit by performing a regression of house prices on available credit. We can include borrower characteristics and hedonic characteristics of the house as variables of control in this regression. This step consists in the estimation of a linear regression of the following form:

$$House\ Price_i = \beta\ Credit\ \ Available_i + \\ +\gamma' X_i + \varepsilon_i$$

The matrix X_i contains an extensive set of real estate and borrower characteristics in order to control for price differences that are due to other factors than the credit available. Below (see section 2) we explain in detail which control variables we use.

1.4 Simulation of a macroprudential intervention

For the simulation exercise we look at various different scenarios (see schedule 1).

First, in line with international efforts and in order to ensure comparability, we look at the impact of each of the three channels separately identified by the market condition. In particular, we look at a 5 percentage point reduction of the prevailing maximum LTV ratio, a 1-year decrease of the prevailing maximum DTI ratio, and a 5 percentage point decrease of the prevailing maximum DSTI. Looking at each channel separately allows us to inspect the impact of each measure. As all three measures are often implemented together and the FMSB also discussed all three policy rates, we additionally combine the three scenarios.

For each scenario, we compute a new value of available credit for each borrower by using the method described in subsections 1.1. and 1.2. We compare the new value of available credit (offered by the bank (i.e. the market)) with the observed credit (actually given to the household) to describe the borrowers who have to exit the market due to the new constraint (if available credit is smaller than observed credit and one cannot fully finance the desired property).

Additionally, we approach the simulation from a different angle (see right-hand part of schedule 1). Here we perform a grid search of policy measures that lead to a decrease of average credit available of 30%. In contrast to the assumptions on debt burden indicators this part is more backward looking in the sense that it assumes a particular outcome (decrease of average credit available of 30%) and looks for the policies needed to achieve it. In practice, various values of policy thresholds (in schedule 1 denoted x, y and z) are used until the desired outcome is achieved. We implement this approach for each

Schedule 1

Summary of the simulation approach

	LTV channel	DTI channel	DSTI channel	Combined	Grid search LTV channel	Grid search DTI channel	Grid search DSTI channel	Grid search combined
LTV	–5 pp	0	0	–5 pp	x	0	0	x
DTI	0	–1 year	0	–1 year	0	y	0	y
DSTI	0	0	–5 pp	–5 pp	0	0	z	z

Note: pp = percentage points.

debt burden indicator separately and for all indicators combined. Note that for the combined exercise there are many possible combinations. As we are interested in the impact of tighter credit conditions on the market we only investigate a decrease of this figure.

We use this new measure for credit available together with the estimates of the house price equation described in subsection 1.3 to simulate the counterfactual house price dynamics under the assumed macroprudential intervention. Hence, while the effect on the price dynamics depends on the house price equation, the change in maximum credit available to households only depends on the observed market conditions.

2 Data and model specification

We use data from the Austrian part of the second wave of the Household Finance and Consumption Survey (HFCS), which was conducted in 2014 and 2015, as the basis of our investigation.[9] The HFCS is a euro area-wide project coordinated by the European Central Bank (ECB).[10] The OeNB is responsible for conducting the survey in Austria. HFCS data provide detailed information on the entire balance sheet as well as several socioeconomic and sociodemographic characteristics of households in the euro area. In particular, the survey provides information on the wealth held in a household's main residence (HMR) and other real estate. In addition to the estimated market price of a particular property at the time of the interview, the survey also collects information about the value of each property at the time when the household acquired (or built) this property. Furthermore, information of potentially multiple loans to finance the HMR of each household is collected as well as outstanding and initial loan amounts and information on interest rates and loan terms. All this information is used in the analysis at hand. We additionally use some specific variables for Austria which are not publicly available, such as, in particular, information on payments into the repayment vehicles of bullet loans, which are not part of the core variables of the HFCS; these data are collected in Austria due to the relatively high prevalence and thus importance of this type of credit. We include such payments into the definition of debt service. We also include Austria-specific information on net income (see below) or region where the household is located to estimate the house price equation. The results reported in this study apply to households in Austria only. All estimates are calculated appropriately taking into account the final household weights and the survey's multiple imputation (see Albacete et al., 2016b, for a detailed description of the survey methodology in Austria). The net sample of the HFCS 2014 in Austria contains 2,997 households. Of these households, about half own their main residence and about 400 (i.e. 15.5% of the household population) have outstanding mortgage debt for their main residence.

Overall, the methodology of the second HFCS wave 2014 follows – with

[9] *A credit register reporting threshold of EUR 350,000 is currently in place in Austria. Since most mortgage loans are below this threshold, this source cannot be used for the analysis at hand. Furthermore, the HFCS has the advantage of providing very detailed information on the characteristics of households and their main residence in addition to the balance sheet including debt information.*

[10] *The first wave of the HFCS in Austria was conducted in 2010 and 2011. As it was implemented with a similar structure, a similar analysis could be conducted with the data from the first wave. It is envisaged that this survey is conducted about every three years and hence the simulation can be updated in the future. The HFCS in Austria has no panel component.*

some improvements – that of the first HFCS wave (2010) and is documented in Albacete et al. (2016b).[11] Thus, for the specifics of the survey the interested reader is referred to the documentation.

For our present analysis, we need to construct three ratios: LTV, DTI and DSTI. For simplicity reasons, we restrict the analysis to mortgages taken out to finance a household's main residence only.[12] As we are interested in these ratios at the time of the origination of the mortgage, we approximate them by using some retrospective information available in the HFCS.

We estimate the LTV by dividing the sum of a household's main residence mortgages at origination by the value of the household's main residence at acquisition.[13] This ratio is called initial LTV and used throughout the analysis. The initial DTI is estimated by dividing the sum of a household's main residence mortgages at origination by the yearly net household income at the time of loan origination. Since the survey only collects information on income for the reference period of the full calendar year preceding the interview (i.e. 2013 or 2014) we use the change of total gross wages from aggregate data[14] between the reference period and the time of loan origination in order to estimate the income at the time of loan origination. This estimation is based on the assumption that the structure of income remains stable. The household's gross annual income is the agreed income measure in the international HFCS. In the Austrian questionnaire respondents are allowed to provide net income figures (for (self-)employment income, pension income, and income from financial assets) if they do not know their gross income; the net figures are then used to calculate gross income figures.[15] During the post-survey production in the second wave of the HFCS in Austria also all gross income figures are converted into net income figures. These net income figures are used in the study at hand. Therefore, the discussion of the main results is based on yearly net household income at the time of loan origination. We also conducted the complete analysis using yearly net income for the reference period (denoted "current income") as well as yearly gross income for both the reference period as well as the time of loan origination. Due to space constraints, the results are not presented here but are available upon request. The DSTI is estimated by dividing the sum of all annual mortgage payments (including savings for bullet loans) for the household's main residence (at the time of the interview) by the household's net annual income (at the time of loan origination). Thus in light of the retrospective view at the time of the loan origination we implicitly assume – due to the lack of additional information – that the repayment is constant over the repayment period and thus ini-

[11] *An extensive methodological documentation of the second wave of the euro area HFCS can be found in ECB (2016).*

[12] *Since there are few mortgages to finance real estate other than the HMR (i.e. only 1.5% of households hold such liabilities, see e.g. Fessler et al., 2016), the inclusion of these loans should not affect the results to a great extent.*

[13] *There is the possibility that there is a time difference between loan origination and ownership transfer. In order not to restrict the sample further and make use of all available information, we take all mortgage loans for the HMR into account independent of potential time differences.*

[14] *More precisely, we use the "compensation of employees" time series since 1954 from the Austrian national accounts statistics, which includes gross wages and salaries plus employers' social contributions.*

[15] *According to the documentation in Albacete et al. (2016b), the Ministry of Finance's "net-gross calculator" is used for this conversion.*

tial repayment is equal to current repayment.

Furthermore, the maximum credit ratios reflecting the prevailing market conditions with respect to the highest ratios that are financed by the banking sector should be given by relatively high percentiles of their distribution. Kelly et al. (2015) propose to use the 98th percentile from the credit register. Because of the structure of the survey and the relatively small number of observations we take the 75th percentile for LTV[16] and the 95th percentile for the other two ratios. We repeat the whole exercise assuming the 80th percentile for the LTV as the market condition for maximum LTV provided. Qualitatively the results below are robust to this variation.

Finally, for the calculation of available credit as laid out in subsection 1.2 we also need to construct the following additional variables: the household's down payment available to the borrower ($deposit_i$), which is defined as the difference between the value of the main residence at the time it was acquired and the initial amount borrowed at the time the loan was granted (this amount may be negative if the initial LTV is larger than 100% for a specific borrower); the interest rate (r_i), which is measured by the current interest rate paid by the borrower;[17] and the maximum loan term allowed by banks for repaying the mortgages (*TERM*), which is measured by the 50th percentile of the maximum[18] loan term distribution across borrowers.

3 Results

This section provides and discusses all empirical results obtained with the methods described above. Important assumptions for the simulation may be repeated in order to underline their relevance and to provide for complete transparency in the choices that need to be made.

3.1 Credit available

First, we need to look at the general market conditions for the HMR mortgage market in Austria as found in the HFCS. Table 1 provides the prevailing market conditions based on the percentiles[19] specified above, the resulting maximum credit available along each channel and the share of households for which the specific channel is binding. It does not only provide the overall structure but also look at a trend over the last years.

The median volume that banks are willing to supply to a borrower applying the LTV criterion (middle panel in table 1) is given by about EUR 924,000. This relatively large amount is due to the relatively high prevailing maximum LTV that the market allows, as can be seen in the 75th percentile of the LTV distribution in the bottom panel in table 1. For instance, if a borrower has a deposit of about EUR 100,000 and the maximum LTV ratio in the banking

[16] *For the estimate of the initial LTV, in particular, one has to consider various specific topics such as the difference in time between loan origination and ownership transfer, acquiring real estate and refurbishing or rebuilding it at the same time, etc. As mentioned above, we take all observations into account, but instead of considering a more extreme percentile, we look more toward the middle of the distribution.*

[17] *If a household has several mortgages, we use the median interest rate of all its mortgages. In particular, we assume a constant interest rate for the repayment period, as given by the information provided in the HFCS.*

[18] *The maximum is only taken if a borrower has taken out more than one mortgage loan for the HMR. This term length of 25 years reflects common practice in Austria.*

[19] *See Albacete and Lindner (2013) for a discussion of credit ratio distributions in Austria.*

Table 1

Descriptive statistics of the components of credit avaliable and the binding condition

	All	1990 to 1994	1995 to 1999	2000 to 2004	2005 to 2009	2010 and younger (2015)
Share of households (%) for which the binding condition is						
LTV	13.6	11.1	12.6	14.0	16.8	14.7
DTI	49.8	43.7	46.2	44.8	51.0	52.6
DSTI	36.6	45.2	41.2	41.2	32.2	32.7
Conditional median of maximum credit (in EUR thousand) given by						
LTV[1]	924.4	768.5	1,069.5	902.0	1,046.0	1,126.5
DTI	367.8	182.3	327.5	374.4	427.5	492.0
DSTI	379.7	180.5	328.9	395.8	431.6	496.9
Market condition of thresholds						
LTV (P75) (%)	90.5	68.5	79.8	100.5	85.4	102.4
DTI (P95) (years)	12.4	9.3	12.5	12.5	11.8	8.6
DSTI (P95) (%)	66.5	60.3	70.4	63.6	60.3	51.4

Source: HFCS Austria 2014, OeNB.

[1] The timeline refers to the year when the highest mortgage for the household's main residence was taken out.

sector is 90%, that borrower will be able to get a mortgage of about EUR 925,000 as indicated above. This figure is regardless of income, age, the prevailing interest rate or credit conditions along the DTI and DSTI channels. Of course, this is a hypothetical exercise because the banking sector would probably not grant such a high loan without considering the other two channels. This is, in fact, what we do when constructing the credit available measure as well.

At the median, the maximum credit along the DTI and DSTI channels is about EUR 370,000 and EUR 380,000, respectively. One has to keep in mind that these results are medians with an underlying complete distribution based on households' individual wealth and income levels (as well as term and interest rate levels for the DSTI channel). Again, these are just hypothetical figures because, of course, the banking sector is unlikely to grant such high loans without considering all three channels together. This is what we do when constructing the credit available measure. This measure is given by the minimum of the three figures in the middle panel of table 1. Thus, at the median overall credit available to a HMR mortgage borrower is about EUR 370,000. Obviously, this figure is well above the median level of initial loan amount at the time of loan origination since not all households need to take out the maximum amount available. In summary, we find in the empirical distributions of the data that the maximum LTV, DTI and DSTI ratios are around 91%, 12 years and 67%, respectively. This does not imply that all potential borrowers may be granted a loan at these ratios. What it does mean can be understood best by considering an example: A household with high and stable income (proven to the bank) may at the maximum reach an LTV of 91% while the other two ratios may be well below the maximum derived from the empirical distribution. On the other hand, a borrower with a very high down payment, e.g. EUR 500,000, may have a relatively high DTI ratio, e.g. 10 years (resulting, for example, from a net income of EUR 20,000 and a mortgage of EUR 200,000). In this example, however, the LTV ratio would be around 29%.

Table 1 also shows which of the three possible channels is binding for the borrower. This depends on individual household characteristics regarding income, wealth and interest rates. We see that for most households the binding channel is the DTI ratio followed by the DSTI ratio. This suggests that policies focusing on these measures have a bigger impact compared to the LTV channel. It also indicates that a bank/creditor looks at the income level in order to estimate the maximum credit to be granted to a specific individual or household. The LTV channel is less frequently binding for households.

The table additionally presents the indicators over time in order to inspect potential changes in the impact discussed below. We find that although income-based borrowing conditions tightened slightly over time, the maximum credit available in absolute terms increased and the share of binding conditions remained stable, and thus the underlying structure seems to be relatively stable as well. This might be an indication that over time, the granting of mortgages increasingly shifted to higher-income households in addition to increasing levels of income over time. When interpreting developments over time, care has to be taken especially with regard to the information on mortgage conditions in the 1990s. As the HFCS collects only data on outstanding loans and households pay back their mortgages over time, the number of observations is low early on (i.e. about 25 in the time bracket 1990–1994) but increases over time (i.e. about 120 in 2005–2009).

We have conducted the whole analysis using current net, initial gross and current gross income levels instead of initial net household income for our calculations. Note that by definition, this impacts only DTI and DSTI. We find that the results are qualitatively stable. Due to space constraints, we do not include all the tables in this paper. Additionally, all the calculations were also conducted with a prevailing market LTV condition of close to 100%. (80^{th} percentile). The results are again stable considering this type of robustness check.

3.2 House price equation

Next we turn to the estimation of the house price model for Austria using HFCS data. We restrict the estimation sample to homeowners with an outstanding mortgage taken out to acquire their main residence so that the estimation sample includes about 400 observations. We do this because the measure of credit available based on all three channels is only available for households holding an outstanding mortgage at the time of the interview. We estimate the equation introduced above with various sets of controls (only the regressions with the largest set of controls are reported in the table) and in levels as well as transformed by the logarithm (or inverse hyperbolic sine transformation for variables that may include non-positive values). As control variables we use a broad set of household and real estate characteristics. The former include age (linear and quadratic), income, down payment and, obviously, credit available to the household. The latter are region, HMR size, time since loan origination, time of living in the household and paradata about the real estate such as type and rating of dwelling as well as rating of the surrounding area and also outward appearance of the real estate as recorded by the interviewer. Table A1 in the annex shows the definition of the explanatory variables in more detail.

Since some of the independent variables are connected we test for multicollinearity. In order to see whether a problem of multicollinearity exists, we have calculated the centered variance inflation factors for the independent variables specified in our linear regression model. Following the rules of thumb used by Chatterjee and Hadi (2012), the only evidence of multicollinearity that we can find in our regression model is the one between age and age squared, which is intended.

The results are presented in table 2.

We find a positive, though partly insignificant relationship between credit available and house prices measured at the time of acquisition. Columns 1 and 2 present the results for the full unrestricted sample. According to our findings, a EUR 1 increase in credit available is associated – ceteris paribus – with an increase in the mean main residence price of about 6 cent in our preferred specification (column 1). Moreover, the relationship between age and house prices follows an inverted U-shaped pattern: on average, initial house prices decrease with age[20] until a certain point, and then increase again, ceteris paribus. To a certain extent, this may also reflect house price developments over the last years. Our results are broadly consistent with the Irish results in Kelly et al. (2015). The corresponding log specification of

Table 2

House price regression

	Full sample		Restricted sample		Unweighted regression	
	Level initial house value	Logarithm initial house value	Level initial house value	Logarithm initial house value	Level initial house value	Logarithm initial house value
	I	II	III	IV	V	VI
Credit available (CA)	0.062	0.332***	0.110	0.339***	0.061	0.351***
	(0.074)	(0.101)	(0.082)	(0.108)	(0.067)	(0.108)
Total household initial net income	–0.137	–0.149	–0.263	–0.139	–0.158	–0.176
	(0.898)	(0.130)	(0.840)	(0.124)	(0.965)	(0.137)
Value of down payment	0.835***	0.040***	0.652***	0.027***	0.880***	0.043***
	(0.186)	(0.007)	(0.218)	(0.006)	(0.116)	(0.006)
Age	–4,200.853	–0.013	–1,455.621	–0.007	–5,445.458	–0.021
	(5,891.842)	(0.026)	(4,164.130)	(0.022)	(4,791.668)	(0.020)
Age squared	33,836	0.000	13,071	0.000	43,119	0.000
	–57,930	(0.000)	–41,382	(0.000)	–48,594	(0.000)
Controlled for[1]						
Region	×	×	×	×	×	×
Time brackets of loan originiation	×	×	×	×	×	×
Size of household main residence	×	×	×	×	×	×
Duration of living in the household main residence	×	×	×	×	×	×
Type of dwelling (paradata)	×	×	×	×	×	×
Dwelling rating (paradata)	×	×	×	×	×	×
Dwelling location (paradata)	×	×	×	×	×	×
Outward appearance of dwelling (paradata)	×	×	×	×	×	×

Source: HFCS Austria 2014, OeNB.

[1] Every regression includes a constant.

*Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1; "x": according control variable(s) included.*

[20] *In the specification, we use the current age of the household's financially knowledgeable person.*

house prices, credit available, income and deposits (column 2) confirms the result, and the estimate on the credit available turns out to be significant. This is due to the lower variability and hence lower standard errors when the log specification of those variables are used. Careful inspection shows that the coefficients of credit available in specifications 1 and 2 translate into relatively similar effects on mean house price.

In order to see how robust the results are against outliers in the LTV, we perform the same regressions dropping the top and bottom percentiles of LTVs in the sample (columns 3 and 4). The general qualitative results of this type of house price equation remain relatively stable. We also show in table 2 a set of additional regressions based on unweighted regressions (columns 5 and 6). Again, the results remain quite stable. The additional robustness checks with current net and gross income as well as initial gross income are not only thought as a general form of robustness checks, but also as a way to provide a broader perspective on the issue under investigation. (All these results cannot be included because of space constraints.) For the same reason we consider various specifications.

3.3 Simulation results

Now we turn to the simulation of macroprudential policy changes (tables 3a and 3b).

The first column in table 3a shows the starting point of the simulation in the baseline scenario with the market conditions found in the HFCS (see also table 1). We first simulate a 5 percentage point decrease of the maximum LTV, followed by a one-year reduction of the DTI and a 5 percentage point decrease of the maximum DSTI. The last column provides the results of the combined scenario, where all the three previously separately analyzed reductions are put into one simulation.

The top panel again (as in table 1) shows the share of binding constraints in each simulation whereas the second panel shows the maximum credit available along each channel in each scenario. The last panel is reserved for the results on the average changes in house prices as well as the maximum credit available due to the change in policy rates.

Table 3a shows that a reduction of the maximum LTV by 5 percentage points reduces the median maximum credit available along this channel to around EUR 550,000 – quite a sub-

Table 3a

Simulation results

	Baseline	LTV 5 pp	DTI 1 year	DSTI 5 pp	Combined I
Share of households (%) for which the binding condition is					
LTV	13.6	23.0	12.9	13.0	20.9
DTI	49.8	43.9	66.2	33.2	46.5
DSTI	36.6	33.2	20.9	53.8	32.6
Conditional median of maximum credit (in EUR thousand) given by					
LTV	924.4	548.8	924.4	924.4	548.8
DTI	367.8	367.8	338.2	367.8	338.2
DSTI	379.7	379.7	379.7	351.1	351.1
Changes in % with respect to					
House prices	.	–0.6	–0.6	–0.3	–1.3
Credit available	.	–5.8	–5.5	–3.2	–12.1

Source: HFCS Austria 2014, OeNB.

Note: pp = percentage points.

stantial reduction. Also, the share of households for which this channel is binding increases substantially. However, the impact on the overall house price level and the maximum credit available is limited. This general picture is similar also for the other two channels, with the DTI channel having the larger impact on credit available and on house prices. Combining all three measures results in a larger impact since now households are affected along all channels at the same time. Thus, a particular household may, for example, have an income high enough to accommodate a change in the maximum DSTI, but at the same time may well be affected by the change in the maximum LTV. The same may hold for other households the other way round. Overall, the modeled changes imply that the share of households for which the maximum LTV is binding increases whilst the share for which the maximum DTI and DSTI is binding decreases. In summary, all results point toward a relatively modest impact of the modeled changes.

As mentioned above we also simulate an average decrease of credit available of 30% (a more restrictive case in terms of reduction of credit available), the results of which are shown in table 3b. The idea behind this discussion is to evaluate the size of a policy change needed in order to generate a certain result.

Thus, we see in the last line of table 3b that the change of credit available always amounts to –30%. This would be associated with lower house prices of about 3%. Columns 2 to 4 show the change needed in each of the three policy measures. A grid search yielded this result. We find that along the LTV channel a reduction of 21 percentage points (starting from around 90% in the baseline market condition) would make this threshold binding for close to 60% of borrower households in the HFCS, and the median maximum credit is reduced to about EUR 210,000. The

Table 3b

Simulating a reduction of available credit of 30%

	LTV scenario	DTI scenario	DSTI scenario	Example of a combined scenario II
Change of				
LTV (percentage points)	–21	0	0	–10
DTI (years)	0	–4.3	0	–2.8
DSTI (percentage points)	0	0	–24.5	–18.0
Share of households (%) for which the binding condition is				
LTV	57.2	8.5	8.5	24.8
DTI	22.9	89.4	0.0	32.3
DSTI	20.0	2.1	91.5	42.9
Conditional median of maximum credit (in EUR thousand) given by				
LTV	208.1	924.4	924.4	379.9
DTI	367.8	240.5	367.8	284.9
DSTI	379.7	379.7	239.8	276.9
Changes in % with respect to				
House prices	–3.2	–3.1	–3.2	–3.2
Credit available	–30	–30	–30	–30

Source: HFCS Austria 2014, OeNB.

same impact in terms of the average change of credit available would be reached over a reduction of the DTI ceiling by 4.3 years or a reduction of the DSTI ratio of almost 25 percentage points. In each case the respective policy rate would be binding for almost all households. In the case of the combined scenario we can see that much smaller reductions in each channel together result in the same decrease in credit available. Note that for the combined scenario we report only one possibility. There are many alternative policy mixes (columns 2 to 4 can be examined, for instance) that might yield the same simulation results.

Again we have conducted robustness analyses with current net and gross income as well as initial gross income. Qualitatively, the results are stable.

3.4 First attempt to analyze potentially affected borrowers

Finally, we provide some first information regarding borrowers that are potentially affected by macroprudential measures. We do that by identifying households that under the combined scenario would no longer be able to finance the full amount actually observed. Since the prevailing market conditions are based not on the maximum observed values but some smaller percentiles, there are a few households (1.5%) that are affected even in the baseline scenario. We define a household as being affected by the scenarios introduced above if the newly derived maximum credit available is below the initial amount of loan taken out.

In table 4 we report some general descriptive statistics of the overall household population, HMR mortgage holders and the group affected by the combined scenario.

We see that households with HMR mortgages are more affluent than the overall population both in terms of wealth as well as current annual gross income and that the ones affected by macroprudential policies are likely to

Table 4

Characteristics of the households affected by macroprudential policy

	All	HMR mortgage holders	Affected households in combined scenario
Share of affected households (%)	100.0	15.5	2.2
Household wealth	*EUR thousand*		
Gross wealth mean	275.7	644.8	487.1
Gross wealth median	100.4	340.6	318.5
Household income	*EUR thousand*		
Gross current income mean	43.3	60.5	46.3
Gross current income median	35.7	54.5	41.0
Household financially knowledgable person – sociodemographics			
Mean age	53	48	48
Median age	54	46	47
Household debt structure			
Median current outstanding debt (EUR thousand)	.	63.1	108.2
Share of vulnerable households – DTA[1]>100% (%)	6.3	1.4	3.3
Share of vulnerable households – DTI>300% (%)	6.2	36.0	62.7
Share of vulnerable households – DSTI>40% (%)	2.6	15.1	37.2
Share of vulnerable households – expenses above income (%)	6.9	12.8	11.1

Source: HFCS Austria 2014, OeNB.

[1] *Debt-to-asset ratio.*

be households that are more affluent than the overall population as well. Within the group of mortgage holders, however, they are less affluent households in terms of both wealth and income levels. We also check several other sociodemographic characteristics not displayed in table 4, but it turns out that the group of affected households seems – with the exception of income and wealth – not to be much different from the average mortgage holder (in terms of, e.g., age). It can also be confirmed that among the affected households in the combined scenario there is a substantial share of households that is identified as potentially vulnerable according to several standard vulnerability measures (e.g. DTA>100%, DTI>300%, DSTI>40%).

Lastly, table 5 shows by how much aggregated debt would be affected. First, we see that 14% of HMR mortgage holders are affected by the combined scenario. In terms of current outstanding mortgage loans at the aggregate level, these households hold about 23% of all mortgage loans. Under the assumption that these households are not going to be excluded from the credit market completely but are just going to reduce the credit amount taken out, we can see that only about 11% of the aggregate mortgage volume initially taken out would not be financed anymore. The two shares basically provide some bounds on the affected loan volume depending on the assumption whether a household – if restricted – just reduces credit amount taken out (3rd row in table 5) or cannot finance the real estate completely and thus is excluded from the credit market (2nd row in table 5). Please note that this exercise does not take into account that the affected households might hold other assets in addition to the considered deposits or might get help from family or friends, which would allow them to finance the property completely and which would further lower the shares shown in table 5.

4 Summary and concluding remarks

In this paper, we adapt the approach developed by Kelly et al. (2015) to the Austrian case and to household-level survey data. Instead of credit register data we use data from the second wave of the Austrian HFCS for 2014/15, which allows us to characterize in detail the households affected by the simulated macroprudential policy measures.

In a first step, we estimate the credit supply of banks to households on the basis of the three standard credit ratio criteria LTV, DTI and DSTI. We find that the income-based criteria (DTI and DSTI) are the ones which are most often binding for Austrian households. Hence, a policy focusing on the

Table 5

Share of aggregate debt held by households affected by macroprudential policy

	Baseline	Combined scenario I
	%	
Conditional share of affected households	9.7	14.0
Aggregate share of total current debt held by affected borrowers in total current household debt	16.6	23.4
Aggregate share of excess initial debt held by affected borrowers on total initial household debt	8.3	11.1

Source: HFCS Austria 2014, OeNB.

LTV ratio is expected to be less effective than limiting the DTI or DSTI.

In a second step, we estimate the house price model and show that the amount of credit that is supplied to each borrower has a positive but small impact on the value of the main residence that is purchased. In other words, mean main residence prices do not seem to be strongly credit driven in Austria. However, it could well be that certain quantiles of the main residence price distribution or main residence prices of certain borrower groups (e.g. foreign currency borrowers) or house prices of other properties than the main residence would still change under such scenarios. This is left for future research.

In a third step, we simulate the impact of macroprudential policy interventions on the Austrian housing market. We consider several scenarios that involve restrictions on each of the following ratios: LTV, DTI and DSTI. According to our findings, in Austria, macroprudential policy interventions would be effective in reducing credit supply to households, but less so in slowing down a rapid increase in house prices. Moreover, the impact on house prices is found to depend on the levels at which LTV, DTI and DSTI limits are set. The analysis just simulates the impact on credit supply and not the impact on the credit actually given to a household or newly granted credit by banks (which would also depend on credit demand and is beyond the scope of this paper).

Finally, we have seen that households who are affected by macroprudential policies in that they would no longer be able to take out the amount of credit that they had originally taken out are less affluent households than the average mortgage holder in terms of both wealth and income levels, but they are still more affluent than the average household in the entire population. Furthermore, these households are more vulnerable in terms of several standard vulnerability measures.

It is left for future research to analyze what the impact of macroprudential policies would be on rental prices. In Ireland, for example, rental prices have strongly increased since the implementation of macroprudential policies (see RTB, 2016). Furthermore, future analyses of this kind for Austria could be extended further if credit register data covering Austrian households' mortgage loans in their entirety or at least to a large extent, including appropriate information on mortgage holders, were available. This would provide a much larger sample and more precise information on the origination of loans and could help inform the process.

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Annex

Table A1

Definition of explanatory variables

Variable name	Variable definition	Subject
Initial house value	Property value at the time of its acquisition in EUR	Household
Credit available	Minimum of LoanLTV, LoanDTI and LoanDSTI (see subsection 1.2)	Household
Income	Total household net income in EUR at the time when the highest mortgage was taken out	Household
Value of down payment (equity capital, down payment)	Value of household main residence in EUR at the time of ownership transfer minus value of household main residence mortgage at the time the mortgage was taken out	Household
Age	Age in years	Reference person
Age squared	Age in years squared	Reference person
Region	1=Vorarlberg; 2=Tyrol; 3=Salzburg; 4=Upper Austria; 5=Carinthia; 6=Styria; 7=Burgenland; 8=Lower Austria; 9=Vienna.	Household
Time brackets of loan origination	1=up to 1989; 2=1990 to 1994; 3=1995 to 1999; 4=2000 to 2004; 5=2005 to 2009; 6=2010 to 2015	Household
Size of household main residence	Size of the household main residence in square meters	Household
Duration of living in household main residence	Period of time the household has already lived in its main residence	Household
Type of dwelling (paradata)	1=detached house; 2=semi-detached house; 3=flat/apartment; 4=other kind of dwelling	Household
Dwelling rating (paradata)	1=luxury; 2=upscale; 3=mid-range; 4=modest; 5=low-income	Household
Dwelling location (paradata)	1=downtown; 2=area between city center and suburbs; 3=outskirts; 4=isolated area, countryside	Household
Outward appearance of dwelling (paradata)	1=generally clean and sound; 2=some peeling paint or cracks in walls; 3=needs substantial painting, refilling or repair; 4=dilapidated	Household

Source: HFCS Austria 2014, OeNB.

Note: The household's reference person is defined as the financially knowledgeable person in the household.