Assessing the impact of macroprudential measures: The case of the LTV limit in Lithuania

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ABSTRACT

In this paper, we adopt a dual micro-and-macro simulation strategy to assess the impact of introducing (or changing) the LTV limit. Due to the nature of borrower-based macroprudential measures, to assess this impact we need to use borrower-level micro data. Tightening (or loosening) the LTV limit increases the share of borrowers constrained by the policy measure in question; thus, the overall impact depends on initial market conditions. We find that the introduction of an LTV limit of 85% in 2011 had a modest short-term impact on economic activity because the new regulatory limit was non-binding for most borrowers at the time. We estimate that if the LTV limit would not have been introduced, the household loan portfolio would have grown on average 1.5 percentage points faster per year (over 2012-2014). This would have led to a 0.5 percentage point higher housing price growth and a 0.2 percentage point higher real GDP growth. When the macroprudential LTV limit is binding for a significant portion of borrowers, lowering the LTV limit at current market conditions has a much more pronounced effect. We show that if the LTV limit had been implemented at the end of 2004, it would have substantially helped in tempering the credit and housing boom, albeit at the cost of lowering economic growth.

Keywords: Financial stability, Macroprudential policy, Borrower-based macroprudential policy instruments, LTV limit.

1 Introduction

The financial crisis of 2008-2009 showed that credit-fueled economic expansions driven by housing price bubbles can have devastating economic and social consequences. This realization led to a wide range of legislative initiatives and institutional changes across the globe. Among the main changes was the introduction and enactment of macroprudential policy. Ultimately, macroprudential policy seeks to safeguard the stability of the financial system as a whole by strengthening its resilience and limiting the build-up of systemic risks. To achieve this aim, many countries introduced macroprudential measures to cope with increasing systemic risks, asset price bubbles, excessive risk-taking, etc. Notably, however, we lack experience with and thus empirical analysis about how such instruments can affect the financial system and the overall economy.

One subset of macroprudential instruments is borrower-based instruments. Borrower-based measures affect the terms and conditions of lending. Those measures can affect lending by imposing limits on the volume of credit granted in relation to the collateral value (loan-to-value limit, henceforth, LTV limit), to the debt service payments of borrowers in relation to their income (debt-service-to-income limit, henceforth, DSTI limit), to the borrower’s total indebtedness, or the volume of credit granted in relation to income (debt/loan-to-income limit, henceforth, D/LTI limit). Borrower-based macroprudential instruments are not harmonised across countries\(^1\), and in various countries can be governed by different laws and have different underlying aims. This makes cross-country comparisons challenging.

The transmission mechanism of borrower-based measures differs somewhat from other macroprudential instruments (e.g. various capital buffers). Policy makers using borrower-based instruments typically intervene in the mortgage market by restricting banks’ ability to issue mortgages with looser credit standards. Thus, borrower-based instruments directly restrict the flow of new loans. Therefore, those instruments can potentially have a significant effect on economic activity. From the financial stability perspective, borrower-based instruments improve the risk profile of new lending, and, over time, they contribute to safer bank loan portfolios.

In Lithuania, an LTV limit of 85% was enacted, with the Bank of Lithuania issuing “Responsible Lending Regulations” at the end of 2011\(^2\). These regulatory changes were initiated with an aim to protect households against imprudent overindebtedness, thereby also reducing overall financial stability risks. Since then, some structural changes in the bank loan portfolio have been observed, such as a significant portion of new loans concentrated in the 80-85% LTV range. The unintended short-term market impact related to stricter LTV requirements was minimal, due to the fact that, in the aftermath of the financial crisis, banks themselves were not willing to extend loans with high LTV ratios. Nonetheless, the impact on the economy has not yet been quantitatively analysed.

This paper contributes to our understanding of how borrower-based measures affect the credit market, and thus economic activity and the housing market. To do so, we adopt a dual micro- and macro simulation strategy to assess the impact of introducing or changing the LTV limit. Due to the nature of borrower-based macroprudential measures, to accurately assess the impact we need to use borrower-level micro data. The novelty of our approach is apparent in two areas. First, we propose a way to assess the loosening of the LTV limit using micro-level data. While a few papers (namely, Cussen et al. 2015, Kelly & O’Toole 2016) discuss how to evaluate the effect of the tightening of the LTV limit on the credit market, to the best of our knowledge, this is the first paper that proposes a way to analyse the loosening of the LTV limit (or analysing the counterfactual situation “what if the LTV limit would not have been introduced”). Second, this is the first quantitative assessment of the effectiveness of the LTV limit in Lithuania. In addition, we address the question of whether the introduction of the LTV limit before the 2008-2009 crisis would have limited the credit boom.

In this paper, we show that if the LTV limit had not been introduced in 2011, the household loan

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\(^1\)Unlike capital-based instruments, borrower-based instruments were not included in the EU harmonised legal framework. Their use is governed by national law, with different institutional set-ups prevailing across the Euro area.

\(^2\)Along with LTV limit of 85%, the Bank of Lithuania also introduced a DSTI limit of 40% and a 40-year limit on mortgage maturity.

\(^3\)At the time, the Bank of Lithuania did not have a formal macroprudential mandate. Nevertheless, the underlying motivation for the introduction of those instruments was to safeguard overall financial stability. (See The Bank of Lithuania approved Regulations for Responsible Lending 2011)
A portfolio would have grown on average 1.5 percentage points faster (over the period 2012-2014). This would have led to a 0.5 percentage point higher housing price growth and a 0.2 percentage point higher real GDP growth. The introduction of the LTV limit in 2011 had a modest immediate effect, as the credit growth at the time was low, credit standards were tight and, consequently, the new regulatory limit was non-binding for most borrowers. However, lowering the LTV limit at current market conditions would have a much more pronounced effect. We also show that if the LTV limit of 85% had been implemented in 2004, it would have substantially helped to temper the credit and housing boom.

The paper is structured as follows: in section 2, we present a literature review; section 3 outlines our methodological approach; in section 4, we discuss data and present the results of our simulations; section 5 presents the cost and benefits of macroprudential policies; in section 6, we conclude.

2 Literature overview

Macroprudential policy impact assessment is a new area of research. There are three main reasons for this. First, thus far, there has been limited experience with macroprudential measures. Second, the availability of loan-level data is limited in most countries; as we will show later, such data is crucial for studying the impact of borrower-based macroprudential policies. The third reason is that interest in financial stability was limited before the global financial crisis. In this section, we discuss various methodologies applied to evaluate the impact of (mostly) borrower-based macroprudential policies on economic activity, credit and housing markets.

Analyzing macroprudential policy changes by including dummy variables. Kuttner & Shim (2016) try to evaluate effectiveness of nine non-interest rate policies (including the LTV limit) on house prices and housing credit using data from 57 economies and periods of up to three decades. They use conventional panel regressions to estimate the effects of the policies, controlling for macroeconomic conditions, other policy actions and price and credit dynamics. They find that reductions in the maximum LTV limit did less to slow credit growth than lowering the maximum DSTI limit. Poghosyan (2019) employs local projections to assess various lending restrictions and finds some evidence for the effectiveness of lending restriction measures (LTV and DSTI) in affecting developments in house prices and credit in a sample of 28 EU countries. However, the impact is delayed and reaches its peak of -1.5% only after three years.

Many papers (Akinci & Olmstead-Rumsey 2018, Jacome & Srobona 2015, Fendoğlu 2017) have used similar strategies to evaluate macroprudential policies. All of them have found that the LTV limit had an effect on the credit and housing markets, although the effects vary quite substantially across the studies. Nevertheless, it is crucial to emphasise that measuring the intensity of macroprudential policy actions using such techniques is difficult, and existing databases usually use dummy or indicator variables for loosening (-1), tightening (+1), or no changes (0) in LTV limits. Thus, using a dummy variable, a decrease in the maximum LTV ratio from 90% to 70% and a decrease from 80% to 75% are treated equally.

Some authors (namely, Richter et al. 2018) try to tackle these drawbacks. Richter et al. (2018) employ local projections to estimate impulse responses to a change in LTV limits. Instead of using a dummy variable, they use the size of changes in LTV limits to estimate the effects of a one percentage point change in LTV limits on output and inflation. They find that a 10 percentage point decrease in the maximum LTV ratio leads to a 1.1% reduction in output after 16 quarters. They also show that a decrease of the LTV limit has a smaller effect on the economy compared to an increase in the LTV limit. Alam et al. (2019) estimate the effects conditioning on the level of LTV limits. The threshold levels sorting loose and tight initial levels are set to 100% - 90%. The results suggest that the initial LTV level matters, especially for household consumption, with the effect of an additional tightening on consumption being larger when LTV limits are already tight. In general, a tightening of LTV limits by one percentage point is only significantly associated with a decline in consumption if the LTV is already tight.

4 Jordà (2005)
5 To exploit novel numerical information on LTV limits, they use a propensity-score-based method to address endogeneity concerns.
All these estimates pertain to the policies’ average effects in a sample of heterogeneous economies. There is no reason to believe the effects will be the same everywhere. As we show later, borrower-based macroprudential policies depend on initial market LTV conditions, which are not properly taken into account in any of aforementioned research.

**Constructing continuous time macroprudential (stance) indexes and using them to evaluate.** Instead of analysing separate changes in levels of macroprudential instruments, some authors, (for example, Akinci & Olmstead-Rumsey 2018, Cerutti et al. 2015) construct a continuous time macroprudential policy stance index. Akinci & Olmstead-Rumsey (2018) construct cumulative indicator variables for individual measures in each country. They created cumulative indexes of housing and non-housing measures, as well as a cumulative index for all macroprudential policy measures in place in a given quarter. These cumulative variables sum the indicator variables (tightenings and loosening) to obtain an idea of a country’s “macroprudential policy stance” in a given quarter. Their findings suggest that provision requirements are effective in reducing bank credit growth, along with LTV limits, risk weights on mortgages, and other housing measures. Only housing-related macroprudential policies, particularly LTV and DSTI limits, constrain housing credit growth and house price appreciation. Cerutti et al. (2015) create an overall macroprudential index which is just the simple sum of the scores on all 12 policies analysed. They find that this index is negatively, and statistically significantly, associated with growth in (real) credit. This suggests that macroprudential policies have significant mitigating effects on credit developments.

However, this approach still provides only limited results which are qualitative in nature, as the results still represent average effects of heterogeneous macroprudential measures in a sample of heterogeneous economies.

**Case studies.** Borrower-based measures such as limits on LTV, LTI and DSTI ratios have been found in the academic literature to have a greater impact on the housing market, compared to capital requirement (see, Fendoğlu 2017). However, these results mostly come from cross-country studies which do not necessarily take all the relevant factors into account in estimating the impact of specific policies. Another strand of literature which is closely related to our paper are studies producing counterfactual simulations on various LTV regulations (see, Wong et al. 2016, Price 2014). Wong et al. (2016) build a disequilibrium model of demand and supply of mortgage loans. They show that LTV limit tightening since 2009 has dampened both the leverage of borrowers and credit growth, and that lower leverage has played a major role in strengthening the resilience of banks to property price shocks. Price (2014) estimate the typical relationships between housing market variables over time, and then use those relationships to predict the likely ‘normal’ behaviour of the housing market, starting from just before the announcement of the LTV limit. They condition the forecasted dynamic on various relevant factors (e.g., migration, economic activity, interest rate) and show that actual housing market activity, house price inflation, and household credit growth have fallen below the estimated counterfactual scenario since the LTV restriction was introduced. However, in contrast to our paper, the aforementioned studies do not use micro-level data. The academic literature is lacking more detailed case studies that use borrower-based macroprudential instruments, which would provide more reliable country-specific results. Notable exceptions are Cussen et al. (2015) and Kelly et al. (2018).

Any borrower-based regulation (e.g., limits on LTV, LTI and DSTI ratios or mortgage maturity) restrains the amount of lending that is available to a borrower. Therefore, at the aggregate level, the effectiveness of such instruments depends on how many borrowers are constrained. As market-imposed lending standards tend to be pro-cyclical, the effect of borrower-based limits differs over the financial cycle. In addition, tightening borrower-based instruments can have a highly non-linear effect, as a tightening policy measure raises the share of borrowers constrained by the policy measure and reinforces the effects of the measure. From a methodological standpoint, in this note we take into account loan-level data and credit standards when estimating the aggregated effects of the LTV limit on the economy. This approach was proposed by Cussen et al. (2015).

Kelly et al. (2018) use loan-level data on Irish mortgages to construct a measure of credit availability that varies at the borrower level as a function of income, wealth, age, interest rates and prevailing market conditions around LTV, LTI and monthly DSTI. They deploy a property-level house price model which shows that a 10 per cent increase in credit available leads to a 1.5 per

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6See Dell’Ariccia et al. 2012 and Ruckes 2004 for a discussion of the pro-cyclicality of lending standards. Matkénaitė et al. (2016) discuss the pro-cyclicality of lending standards over the cycle in Lithuania.
cent increase in the value of property purchased. Coefficients from this model are then used to fit values under scenarios of macroprudential restrictions on LTV, LTI and DSTI on credit availability and house prices in Ireland for 2003 and 2006. Their results suggest that macroprudential limits would have had substantial impacts on house prices, and that both the level at which they are set and the timing of their introduction are crucial determinants of their impact on housing values.

Cussen et al. (2015) employ a dual micro and macro simulation strategy and find evidence for some moderate negative impacts of the LTV limit on house prices and mortgage interest rates, with a proportionately larger impact on housing supply. First, they simulate the possible effect on mortgage flows; then they take the micro-simulation result and impose it as a shock in a model which includes new mortgage lending, house prices, housing completions, the mortgage interest rate and the unemployment rate. They calibrate the initial shock to the BVAR model - a reduction of 9 per cent in the value of new mortgage lending in the quarter in which the proposed LTV limit is implemented. The effect on house prices is longer and more pronounced. After the first year, house prices are approximately 0.8 per cent lower than in a “no policy change” context, with that effect rising to 1.3 per cent after three years before tapering off. House prices are permanently lower after the introduction of the LTV limit when compared to the baseline of no LTV limit.

All in all, various case studies incorporate the available data and take into account relevant country specificities. This leads to better and more realistic estimations, compared to the cross-country studies discussed above. In the following section we present our methodological approach, which is mostly inspired by Cussen et al. (2015) and Kelly & O’Toole (2016).

In our literature review, we focused mainly on studies analysing the impact of the introduction of a limit on LTV to macroeconomic factors. The LTV limit is also analysed from other angles (for example, Acharya et al. 2020, de Araujo et al. 2020, Montalvo & Raya 2018). Montalvo & Raya (2018) show that LTV regulation before the onset of the housing crisis of 2008 did not prevent that feedback loop. Appraisal companies were mostly owned by banks, leading to a situation in which LTV limits were used to generate appraisal values adjusted to the needs of the clients, rather than trying to appropriately represent the value of the property. This tendency towards over-appraisal produced important externalities in terms of a higher-than-otherwise demand for housing, and an intensification of the feedback loop between credit and house prices. de Araujo et al. (2020) use loan-level data to explore the impacts of the LTV limit on constrained individuals using the difference-in-difference estimator. They show that, in Brazil, individuals cope with the new LTV limit by making higher down-payments and also purchasing more affordable houses. LTV limits are thus effective macroprudential tools because they lower the risk of some originated housing loans. Acharya et al. (2020) show that the introduction of LTV and LTI limits in Ireland has caused a substantial reallocation of mortgage credit. They document the reallocation of mortgage credit from low- to high-income households and from hot, mostly urban, housing markets to cool housing markets. This reallocation is effective in slowing down house price growth, and in turn, the feedback loop between mortgage credit and house prices.

3 Methodology

The methodology used in this paper is largely inspired by Cussen et al. (2015) and Kelly & O’Toole (2016), as these authors use micro-level data to analyse the macro-level effects of macroprudential policy intervention. Nevertheless, there are some notable differences in our approach. Kelly & O’Toole (2016) use micro-regressions to estimate the effects, whereas we use macro models (VAR). Cussen et al. (2015) use a VAR model but they treat changes in mortgage flow as a credit shock, while we conditionally forecast other relevant macro time series. Cussen et al. (2015) and Kelly & O’Toole (2016) analyse the effects of policy tightening. In contrast to those studies, we also analyse some hypothetical scenarios of (ex-ante) loosening of the LTV limit. We know of no other attempts to analyse loosening the LTV limit in a “micro-macro” setting (using micro-level data). In this section, we present the methodology used in this paper.

The introduction of limits on LTV has a direct impact on the conditions upon which new mortgage loans are granted, thus affecting the maximum amount of a new mortgage loan available to the borrower. Therefore, it is crucial to use micro-level data to understand initial lending conditions, if one wants to fully understand how many borrowers are (or would be) constrained by
an LTV limit. Based on this, our approach consists of two consecutive steps:

- First, we evaluate how policy tightening/loosening of the LTV limit would change the market LTV distribution, and how this would affect the mortgage flow;
- Second, making some assumptions about the amortisation of mortgage stock, we calculate the counterfactual dynamics of mortgage loans. Then, we conditionally forecast various time series (namely GDP and housing price index) on counterfactual mortgage series using a VAR model.

The advantage of this two-stage approach is that we take into account micro-level data while evaluating the aggregated macroeconomic effects. This allows us to capture the non-linear effect of tightening the LTV limit while still using an intuitive and simple linear macro model. We discuss each step in more detail.

### 3.1 Evaluation of how policy tightening/loosening would affect market LTV distribution

Tightening borrower-based instruments can have a highly non-linear effect, as a tightening policy measure raises the share of borrowers constrained by the policy measure and reinforces the effects of the measure. At the aggregate level, effectiveness depends on how many borrowers are constrained. The flow of new mortgages at any point in time is simply the sum of all individual mortgages issued at this time. Any individual mortgage depends on (i) the price of underlying collateral and (ii) an LTV with which the banks and individual borrowers would agree to make new mortgage loans. Therefore, the flow of new mortgages in the absence of a regulatory LTV limit could be expressed as:

\[
flow_{\text{unconstrained}} = \int_0^\infty n(L^D) \cdot L^D \cdot P(L^D) \, dL^D, \tag{1}
\]

where \(L^D\) denotes the desired LTV ratio \(L^D \in [0, +\infty]\), \(n(L^D)\) denotes the number of borrowers who want to borrow with a specific LTV ratio \((L^D)\), and \(P(L^D)\) denotes the average value of property used to collateralise mortgages.

The introduction of an LTV limit prevents the issuance of high LTV ratio mortgages; therefore, the impact of this introduction depends on borrower’s behaviour. One must consider various scenarios to take into account potential borrower behaviour. For example, if a borrower desires to take a mortgage with an LTV ratio of 85 percent but the bank is required to offer a mortgage with an 80 percent LTV ratio, the borrower may decide to: (i) accept the offer and use alternative funds to make up the shortfall in the purchase price of the property, or buy a less expensive dwelling; or (ii) reject the offer and forego purchasing the property\(^7\). In any case, this constrains the new mortgage flow.

If all borrowers who would be constrained by the new LTV limit were to decide not to take loans, tightening the LTV limit would have a massive impact. However, it is more likely that at least some (if not all) constrained borrowers take a mortgage with an LTV ratio that is equal to the new LTV limit. Nevertheless, this effect is likely to depend on how close to the limit the individual borrower is. If, prior to the new regulation, the borrower was close to the limit - say, for example, he sought a loan with an LTV ratio of 90 per cent - it is quite likely that he would accept a loan with an 85 per cent LTV ratio. In contrast, if the borrower sought a loan without any initial mortgage deposit (an LTV ratio of 100 %), and the new regulatory LTV limit was 85%, it would be less likely that such a borrower would take a loan, as he would have to come up with a substantial deposit.

Following Cussen et al. (2015), we try to approximate this borrower’s behaviour by assuming the form of borrower behaviour function. We assume the following behavioural function for borrowers

\(^7\)This can also delay the mortgage application for the period in which the additional deposit funds are accumulated. While this would be significant if we analyse the long-term effects of LTV limits, in this paper we focus on the short-term effects.
based on the difference between their desired LTV ($L_D$) and the maximum LTV possible under the new regulation $\bar{T}$. We use the following formula to describe their behaviour:\footnote{This rule is less restrictive than that of Cussen et al. (2015), who use a more exponentially restricting rule: $\alpha = 1/(L_D - \bar{T})$. See Annex A for a comparison of those functions. While our behaviour function is assumed, there is some evidence for both effects in the literature. de Araujo et al. (2020) provide evidence that individuals cope with new LTV limits by making higher down-payments and also purchasing more affordable houses. Morgan et al. (2019) show that LTV policies lower mortgage origination activity.}\footnote{As in Cussen et al. (2015) we assume that potential new borrowers have a similar demand for mortgages based on the characteristics of loans issued in our sample.}

$$\alpha(L_D, \bar{T}) = \frac{0.8^{(L_D - \bar{T})/5}}{5}$$

(2)

This functional specification would mean that the greater the difference between desired LTV ($L_D$) and the new regulatory limit ($\bar{T}$), the higher the chance that the borrower will not take a loan ($\alpha$). If the borrower intends to take a mortgage with an LTV ratio of 90% and the new limit on LTV is 80%, there is a 64% chance that he will take a mortgage. If the borrower intends to take a mortgage with an LTV ratio of 100% and the new limit on LTV is 80%, there is a 41% chance that he will take a mortgage.

If there is a regulatory limit on LTV in place, it splits new borrowers into two groups: (i) those who are not affected by the regulatory LTV limit (they would want to take a mortgage with an LTV ratio which does not exceed the LTV limit ($L_D \leq \bar{T}$)), and (ii) those who are affected by a regulatory limit on the LTV, as they want to take a mortgage with an LTV ratio which is higher than the LTV limit ($L_D > \bar{T}$). If we assume that a constrained borrower takes a loan with an LTV ratio which is equal to the LTV limit, with a probability $\alpha(L_D, \bar{T}) \in [0, 1]$, we can express the flow of new mortgage loans as:\footnote{By using this equation, we are assuming that there are no feedback loops between the average value of property (price) of housing $P(L_D)$ and the LTV limit or macroeconomic factors. This is obviously not true, as tightening the LTV limit: (i) limits the new mortgage flow and lowers the GDP growth and housing price; and this, in turn, (ii) lowers mortgage flows even more. Nevertheless, we capture just the initial effect (i), but we do not capture the feedback loop (ii).}

$$\text{flow}^{\text{constrained}} = \int_{0}^{\bar{T}} n(L_D) \cdot L_D \cdot P(L_D) \, dL_D + \int_{\bar{T}}^{\infty} \alpha(L_D, \bar{T}) \cdot n(L_D) \cdot L \cdot P(L_D) \, dL_D$$

(3)

If we know all the characteristics of loans underlying the mortgage flow in formula (1) we can recalculate the counterfactual flow with any LTV limit. In Fig. 1, we show a stylised example of an introduction of the LTV limit. In this example, we assume that we know the market LTV distribution prior to policy changes (Fig. 1a). If we introduce an LTV limit of 80%, borrowers who are constrained by this LTV limit are forced out of the market or take a mortgage with a lower LTV ratio. This leads to constrained market LTV distribution (Fig. 1b). If we tighten the LTV limit further (to 65%) (Fig. 1c), this will affect even more borrowers, since now more borrowers are constrained by the previously imposed LTV limit. This generates a non-linear effect on credit.

Figure 1: Hypothetical effect on market LTV distribution by an introduction (or tightening) of the LTV limit
Those hypothetical tendencies presented in Fig. 1 can also be seen in the data. An LTV limit in Lithuania was introduced at the end of 2011. Fig. 2a shows the distribution of the LTV ratio one quarter before the introduction of the LTV limit of 85%, and 2b shows the LTV distribution one quarter after the introduction of the LTV limit of 85%.

Figure 2: Distribution of LTV ratio of new mortgages before and after introduction of LTV limit

If we are analysing the loosening of the LTV limit, or analysing the "what if" case in which the LTV limit had not been introduced, we have to assume the path of LTV distribution in the absence of policy change. A natural assumption would be to say that the distribution of the new mortgage LTV ratio would not change over time, as the data shows that it is quite persistent and slow-moving. However, if we wish to evaluate the introduction of the LTV limit in Lithuania in 2011, this assumption is not appropriate. After the crisis, the LTV distribution was shifted left (towards less risky borrowing), as lenders did not want to issue mortgages with high LTV ratios. However, this has been changing; lending standards were relaxed during 2010-2011, and banks started to issue mortgages with higher LTV ratios. To capture this economic recovery phase, we make an assumption about the steady state distribution of market LTV, and the speed with which the LTV distribution - if unconstrained by an LTV limit - reaches the steady state. We assume that the distribution of LTV tends to smoothly converge to the steady state over 10 quarters. We approximate the steady state distribution of LTV ratios by an average of 2005 to 2018 years market distributions. (See Annex B for a discussion of the approximation of steady state distribution of LTV ratios.)

Figure 3: Hypothetical effect on market LTV distribution by a loosening of LTV limit

When analysing the case of LTV loosening, it is worth noting that the new post-LTV-loosening distribution is driven by two factors (see Fig. 3). First, some of the borrowers who take mortgages

\[\text{Loosening of the LTV limit also induces some new borrowers to take mortgages}\]

11The introduction of the LTV limit was announced in September, and was enacted in November.
with an LTV ratio that is equal or close to the LTV limit (Fig. 3a) will most likely take mortgages with higher LTV ratios (Fig. 3b). Second, the LTV distribution is also driven by new borrowers, who would be not able to borrow with an LTV limit (Fig. 3c). We assume that new borrowers entering the market can be approximated using the logic of formula (2)\(^12\). The more the LTV limit is loosened, the more new borrowing drives the new distribution.

### 3.2 Evaluating effect of the LTV limit on mortgages, GDP and housing prices

#### Linking mortgage flow with mortgage stock.
Knowing how changes in the LTV limit will affect market LTV distribution, and having made the aforementioned assumptions about new borrowers, we can recalculate the counterfactual mortgage flows. For example, if an LTV limit was already introduced and we want to evaluate the impact of additional tightening, we proceed as follows. First, we can decompose the actual credit flow using the following formula:

\[
flow_{t}^{\text{flow}} = \int_{0}^{T_1} n_t(L_t^D) \cdot L_t^D \cdot P_t(L_t^D) \, dL_t^D + \int_{T_1}^{\infty} \alpha(L_t^D, \bar{T}_1) \cdot n_t(L_t^D) \cdot \bar{T}_1 \cdot P_t(L_t^D) \, dL_t^D
\]  

(4)

where \( t \) is the time analysed. If you lower the LTV limit \( \bar{T}_1 \rightarrow \bar{T}_2 \), where \( \bar{T}_1 > \bar{T}_2 \), you could express the counterfactual mortgage flow as:

\[
flow_{t}^{\text{flow}} = \int_{0}^{T_2} n_t(L_t^D) \cdot L_t^D \cdot P_t(L_t^D) \, dL_t^D + \int_{T_2}^{T_1} \alpha(L_t^D, \bar{T}_2) \cdot n_t(L_t^D) \cdot \bar{T}_2 \cdot P_t(L_t^D) \, dL_t^D

+ \int_{T_1}^{\infty} \alpha(L_t^D, \bar{T}_2) \cdot n_t(L_t^D) \cdot \bar{T}_1 \cdot P_t(L_t^D) \, dL_t^D
\]

(5)

As we know,\(^13\) the actual mortgage flow \( flow_{t}^{\text{flow}} \), we can recalculate the counterfactual \( flow_{t}^{\text{flow}} \). Consequently, we can calculate the counterfactual dynamics of the stock of mortgage loans.

We link the stock and flow using this formula:

\[
stock_{t}^{\text{stock}} = stock_{t-1}^{\text{stock}} + flow_{t-1}^{\text{flow}} + \gamma_t \cdot stock_{t-1}^{\text{stock}}
\]

(6)

We assume that LTV regulations do not impact the maturity and payments of the loans; therefore, the pace of the amortisation (\( \gamma_t \)) of loans does not change. If we are analysing counterfactual scenarios, we use the actual amortisation rate, which can be observed in the data. If we are analysing hypothetical scenarios, and we do not have actual amortisation data available, we assume that the outstanding stock of loans is amortised at the same rate as the average rate of the previous years. By doing so, we assume that the average maturity of the portfolio does not change.\(^14\)

#### Estimating counterfactual dynamics with a macro model.
We use the counterfactual credit stock series to estimate the effects of an LTV limit on housing and credit using a BVAR model.\(^15\) VAR models proposed by Sims (1980) constitute a relatively agnostic class of models which allow the "data to speak", as no tight cross-equation restrictions are imposed. However, we get a model which fits the data reasonably well. We estimate a reduced-form VAR model, where each dependent variable is regressed on its own lags and on the lags of the other variables. In a vector notation, this can be expressed as follows:

\[\beta^L \cdot \{L_t \} = \{L_{t-1} \} / \beta, \text{ where } \beta^L \text{ denote a part of new lending at every } L_t^D, \text{ which drives the convergence to the steady state distribution of lending standards. } \beta^L \in [0, 1]\]

\(12\)We actually approximate it by formula: \(\beta^L \cdot \{L_t \} = 1 - 0.8 \{L_{t-1} \} / \beta\), where \(\beta^L\) denote a part of new lending at every \(L^D\), which drives the convergence to the steady state distribution of lending standards. \(\beta^L \in [0, 1]\)

\(13\)If we do an \(ex-ante\) analysis, we forecast \(flow_{t}^{\text{flow}}\) using a VAR model. If we want to conduct an \(ex-post\) evaluation of the impact of the LTV limit, we could use actual credit data. If we want to evaluate policy impact \(ex-ante\), we do not have the actual data. Thus, we initially forecast the credit stock and calculate a credit flow assuming a constant reimbursement rate.

\(14\)In addition, we assume that unscheduled principal payments is a constant percentage of the portfolio. If we use forecasts, we assume a constant amortisation rate of 2.9% per quarter, which is consistent with the data.

\(15\)We use the alternative – adjusted after the introduction of a limit on LTV – credit series to conditionally forecast the other series (housing prices and GDP), while thinking that differences are driven by housing and credit shocks.
\[
y_t = c + \sum_{i=1}^{p} A_i y_{t-p} + u_t
\]  

(7)

where \(y_t\) is a \(N\cdot1\) vector containing all \(N\) endogenous variables, \(c\) is a \(N\cdot1\) vector of constants, \(A_i\) (for \(i = 1, \ldots, P\)) are \(N\cdot N\) parameter matrices, and \(u_t\) is the \(N\cdot1\) one-step ahead prediction error with \(u_t \sim N(0, \sigma)\), where \(\sigma\) is the \(N\cdot N\) variance-covariance matrix. The vector of \(y_t\) contains the endogenous variables\(^{16}\) – CPI index, real GDP, MFI loans to households\(^{17}\), housing price index, and mortgage interest rates\(^{18}\). The correlation of the residuals \((u_t)\) reflects a contemporaneous relation between the variables. The model is estimated in log levels (except the interest rate) on seasonally adjusted quarterly data from 1999Q1 to 2018Q3. The model was estimated using two lags that were selected using standard optimal lag selection criteria.

We estimate the VAR model using Bayesian techniques to avoid overparameterization. Many authors, starting with Litterman (1985), use the BVAR model to overcome the over-parameterization problem. Karlsson et al. (2013) provides an extensive literature on forecasting using Bayesian VAR models. Karlsson et al. (2013) shows that Bayesian VAR models forecast better than VARs estimated with frequentist techniques. The widely used Minnesota prior introduced by Litterman (1979) is a data-centric prior belief that shrinks the parameters towards a stylized representation of macroeconomic data, thereby reducing uncertainty and improving forecast accuracy. We employ the Minnesota prior in our analysis, where we implement the Bayesian variants of classical VAR models. We use the BVAR methodology because it allows us to take into account the uncertainty associated with all the modelling decisions (see, Giannone et al. 2015). For a technical description, see Dieppe et al. (2016).

Conditional forecasts are defined as forecasts obtained by constraining the path of certain variables to take specific values. Conditional forecasts are obtained conditional on given values for a subset of variables, over a subset of periods. This technique is very useful when one wants, for instance, to simulate a scenario for specific variables and observe the outcome for other variables, or compare the differences in outcomes obtained from different scenarios. In the literature, the technique is used to obtain conditional macro series for different interest rate paths (for example, see Giannone et al. (2019); Giannone et al. (2014) or Clark & McCracken (2014)). In our case, we use a counterfactual credit series to evaluate effects on other variables of interest. The conditional forecasting algorithm in a Bayesian setting was proposed by Waggoner & Zha (1999). For a technical description, see Dieppe et al. (2016)\(^{19}\).

The counterfactual series of the GDP and house prices are constructed as follows:

1. We estimate a VAR model using the sample 1999Q4 - 2018Q3.
2. We assume that mortgage dynamics in Lithuania are known for the whole sample, while all other variables are only observed until the introduction of the LTV limit.
3. We compute counterfactual mortgage series as explained in section 3.2
4. We then compute the conditional forecasts of all variables using the counterfactual mortgage series.

It is crucial to notice that the coefficients of the VAR model are kept fixed throughout the whole exercise.

\(^{16}\)The selection of variables is in line with the literature analysing the housing market in VAR models (see Walentin 2014)

\(^{17}\)In our VAR model, we use MFI loans to households instead of mortgages for two main reasons. First, and most important, is the issue of data availability. Mortgage data is available from 2004, while households’ credit data is available from 1999. This is important because we do not have a long time series, which is required for a VAR model. Therefore, if we use mortgage data, we will not be able to do certain simulations. The second reason concerns general interchangeability. On aggregate, about 80 percent of households’ credit is mortgages. Moreover, mortgage dynamic is closely related to households’ credit (similar growth rate (see fig. 4a)). Also, households with initial mortgages tend to borrow additional funds to renovate their new housing. It is for these reasons that we use the MFI loan series in our baseline specification. Nevertheless, to examine the robustness of our results, we estimate the model with mortgages. We do not see significant changes in the simulations that we were able to do.

\(^{18}\)In our main specification we use mortgage interest rates, but we also estimate the model with EURIBOR as an exogenous variable and mortgage spreads over EURIBOR as an endogenous variable. Such changes in model specification do not significantly affect our results.

\(^{19}\)We use the BEAR toolbox (Dieppe et al. 2016) to estimate our model and to do simulations.
4 Simulation and data

In this section, we present data and do various simulations. First, we present the data and market structure, and discuss the evolution of the market LTV ratio during the period 2005-2018. Next, we describe the regulation which took place in 2011. Then, we analyse the impact of introducing the LTV limit in Lithuania in 2011. In addition, we analyse a few hypothetical scenarios of tightening and loosening of the LTV limit in 2016. Lastly, we analyse the counterfactual scenario of introducing an LTV limit of 85% at the end of 2004, during the upturn of the economic and financial cycle.

4.1 Evolution of the mortgage market and the dynamic of market LTV in Lithuania

**Mortgage market market.** The housing market structure in Lithuania differs somewhat from that of other EA countries. Lithuania had a higher than 90 percent homeownership rate in 2013 (Kulikauskas 2016). There are two main reasons for this: (i) Lithuanian households prefer owning a house to renting; and (ii) the large-scale privatization that followed the break-up of the Soviet Union, during which most households got the flats in which they were living. The large-scale privatization of housing at the beginning of 90s led to a diminished need for mortgages for that generation. Thus, Lithuania has a large share of homeowners without mortgages as compared to the average in the EU. The mortgage market began to develop around 2004. The mortgage stock growth reached around 60 percent on average in 2005-2008, as it started from very low levels (see fig. 4a). The mortgage-to-GDP ratio in 2004 was 3 percent, and started to rise quite significantly (see fig. 4b).

**Introduction of Responsible Lending Regulation.** During the economic boom in 2005-2008, the growing imbalances were not easy to identify because many economists and international institutions thought that the growth of credit in Lithuania was just a natural convergence to EU averages. Nevertheless, after the crisis, everyone agreed that pre-crisis trends were unsustainable. To avoid the unsustainable credit growth over recovery, the Bank of Lithuania in 2011 approved ”Regulations for Responsible Lending”. This regulation aimed at protecting the population against an imprudent assumption of the financial burden, as well as reducing the probability of shocks to the financial system and at the same time to the national economy as a whole. These rules for lending outlined limits that credit institutions were not allowed to breach when issuing loans to natural persons and evaluating their solvency.

The Regulations establish that the loan-to-value (LTV) of pledged assets ratio of credits for the acquisition of assets cannot exceed 85 per cent of the market value or price of pledged assets (when calculating this ratio, a smaller indicator will be applied). The maximum amount of the monthly credit repayment and interest contribution of the credit beneficiary shall (according to all liabilities) be not more than 40 per cent of the entity’s income recognised as sustainable, and the maximum credit maturity cannot exceed 40 years (it was adjusted to 30 years in 2015). In general, the regulation was well received by the financial sector and borrowers, as it set limits which were not binding at the time. Also, the financial sector was in favour of such regulation because it established a clear standard that helped to avoid unsustainable competition.

**Available micro data** The Bank of Lithuania manages the Loan-Risk Database. All credit institutions are obliged to provide data on any loans that they have issued above 1000 euro. Such institutions are further required to report any significant changes in existing loan contracts (e.g. changes in maturity, loan amount, underlying collateral, currency, etc.). The database is updated daily. In this paper, we use this database and, thus, have access to loan-level mortgage data from the start of 2005.

**Evolution of market LTV.** As Matkénaitė et al. (2016) shows, the dynamics of the market LTV ratio in Lithuania exhibited clear pro-cyclicality. There is a positive relationship between the average market LTV ratio and GDP growth, lending activity and housing prices. Individual LTV ratios of many mortgage loans extended during the episode of unbalanced economic growth in 2005-2008 were large, and in some cases there were no down-payment requirements at all during this period. About 40% of mortgage loans were issued with an LTV ratio which exceeded 85% (see Fig. 5). However, during the financial crisis, banks tightened their credit standards and
issued loans with at least a 20-30% initial down-payment; thus, with LTV ratios of 80-70%. A macroprudential LTV limit was enacted, just after economic recovery, during which banks’ credit standards were still relatively tight. After the introduction of the new regulation, credit standards became looser as the economy recovered (the weighted LTV ratio increased). Nevertheless, the banks were constrained by a new regulation; thus, a significant portion of new loans began to concentrate in the 80-85% LTV range.

The pro-cyclicality of market-imposed lending standards means that the effect of the regulatory LTV limit differs across the economic cycle. Therefore, even a static LTV limit can have an anti-cyclical effect, because during economic upturns lending standards tend to loosen up, making the LTV limit binding for more borrowers. In contrast, during economic downturns, credit standards tend to be relatively strict, and the LTV limit can become less binding. It is worth noting that loosening the LTV limit during economic downturns with the goal of boosting housing credit and, thus, economic activity, may not be productive because market-imposed lending standards during downturns tend to be relatively strict.

4.2 The impact of introducing an LTV limit in Lithuania

Making the assumptions presented in section 3, we calculate the counterfactual evolution of the market LTV ratio if the LTV limit had not been introduced. Results are provided in Fig 6b (the actual LTV dynamics are provided in Fig. 6a). The introduction of the LTV limit was non-binding for most borrowers at the time. It can be seen (Fig 6b) that just a small portion of loans (around
20%) were issued above the introduced limit. Moreover, most loans above the regulatory limit had an LTV ratio of 90%. However, the lending standards were still relatively strict in 2011 (compared to 2005-2008); thus, it is natural to assume that lending standards would have relaxed if the LTV limit had not been introduced.

Knowing the counterfactual distribution of the market LTV, we calculate the counterfactual new mortgage flow and mortgage stock (See Fig. 7a and 7b). It is worth noting that the changes in mortgage flow are driven not only by bigger loans which otherwise would be smaller, but also by new borrowers entering the market. The LTV limit forces borrowers to make a significant initial deposit, which excludes borrowers without this deposit from getting a mortgage. If there had not been an LTV limit, banks would issue loans without (or with lower) initial deposits compared to the actual case. Knowing the counterfactual dynamic of mortgage loans, we get conditional values for the real GDP (Fig. 7c) and housing price index (Fig. 7d).

Quantitatively, we estimate that if the LTV limit had not been introduced, MFI loans to households would have been 4.1% (323 million Eur) higher at the end of 2014 (after 3 years). The lending growth over 2012-2014 would have been on average 1.5 percentage points higher. This would have led to an 0.5 percentage points higher housing price growth on average. The effect on GDP is less pronounced - it would have grown on average 0.2 percentage points faster. Quantitative results are provided in Table 1.20

Overall, the introduction of the regulatory LTV limit at the end of 2011 had a relatively negligible short-term impact on credit, house prices and economic activity. This is mainly driven by the fact that the introduced LTV limit was largely non-binding for most borrowers at the time. However, it should be noted that the short-term impact could have been substantially higher if the LTV limit had been binding for most borrowers.

20It is important to note that the effectiveness of the macroprudential LTV limit depends on an accurate evaluation of underlying property. Banks could avoid the regulation by just overvaluing the property (see, for example, Montalvo & Raya (2018)). The legal acts of regulation try to prevent such cases in Lithuania. The Regulations establish that the loan-to-value of pledged assets ratio of credits for the acquisition of assets cannot exceed 85 per cent of the market value or the price of pledged assets (when calculating this ratio, a smaller indicator will be applied).
Figure 7: Impact of changing LTV limit at the end of 2011
Note: Solid black line denotes the actual relevant series (from 2016Q1 it is forecast by our BVAR model). Green dotted line denotes the counterfactual scenario if the LTV limit would have loosened to 95%. Red dotted line denotes the counterfactual scenario if the LTV limit had tightened to 75%.

Table 1: Assessment of the impact of introduction of LTV limit

<table>
<thead>
<tr>
<th></th>
<th>Actual (with introduction of LTV ratio)</th>
<th>Counterfactual (without introduction of LTV limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH credit stock (Bn. Eur)</td>
<td>HH credit growth (%)</td>
</tr>
<tr>
<td>2011*</td>
<td>7.7</td>
<td>-2.3%</td>
</tr>
<tr>
<td>2012</td>
<td>7.5</td>
<td>-3.1%</td>
</tr>
<tr>
<td>2013</td>
<td>7.4</td>
<td>-0.5%</td>
</tr>
<tr>
<td>2014</td>
<td>7.5</td>
<td>1.1%</td>
</tr>
<tr>
<td>Cumulative</td>
<td>(2012-2014)</td>
<td>-0.19</td>
</tr>
</tbody>
</table>

Note: The introduction of the LTV limit was announced in September, but took effect from November of 2011. Therefore it had a small effect in 2011.

4.3 Assessment of potential tightening/loosening of the current LTV limit

In this section, we assess how changing the LTV limit would affect the economy when the LTV limit is binding for a significant portion of borrowers. We analyse two hypothetical scenarios of changing LTV limits in Lithuania and compare them to the "no policy change" scenario. In a "no policy change" scenario, we assume that the market LTV ratio remains stable over the analysed period and that the regulatory LTV limit will not be changed.

- Tightening of LTV limit to 75%
- Loosening of LTV limit to 95%

Tightening the LTV limit to 75%. Fig. 8 show how the market LTV would change under different policy regimes if the LTV limit had been changed at the end of 2016. We show that tightening the LTV limit would have led to a further truncation of market LTV distribution. If
the LTV limit had been tightened to 75%, it would have led to more than 50% of borrowers taking mortgages with an LTV ratio of 75%. Moreover, there would be some borrowers who would not take a mortgage, as it would require a higher initial deposit. Therefore, tightening the LTV limit would have had an immediate effect on new mortgage flow.

Tightening the LTV limit to 75% would have a significant effect on new mortgage issuance, which would be around 30% lower compared to the "no policy change" scenario (See Fig. 9). In this case, the portfolio of MFI loans to households would grow 6.2% (on average 2% per year) over 3 years, compared to 23.1% (on average 7.2% per year) in the "no policy change" scenario. This would translate into lower house price growth, which would be on average 1.6 percentage points lower over 2017-2019, and lower GDP growth, which would be on average 0.69 percentage point lower compared to the "no policy change" scenario. Quantitative results are provided in Table 2.

Loosening the LTV limit to 95%. In contrast, if the current LTV limit had been loosened to 95%, borrowers would have been able to take mortgages with higher LTV ratios. After a policy change, it would take, by assumption, 10 quarters to converge to the new market LTV distribution. In addition, distributional changes would also be induced by new borrowers who would come to the market because they need a smaller initial deposit. Nevertheless, the changes would be gradual, as it would take some time for banks to adjust their lending policy. Quantitatively, this means that after 10 quarters (when steady state is reached), around 35% of new loans would be issued above 85% and about 20% of loans would be issued with an LTV ratio of 95%.

Loosening the LTV limit to 95% would have a less significant effect on new mortgage issuance because it would take some time for banks to fully adjust to a new regulatory regime (See Fig. 9). On average, the new mortgage issuance would be around 14% higher, compared to the "no policy change scenario", while in the first year the effect would be lowest. In this case, the HH loans portfolio would grow around 32.5% (on average 10.4% per year) over 3 years, compared to 23.1% (on average 7.2% per year) in the "no policy change" scenario. This would translate into higher house price growth, which would be on average 1 percentage point higher, and higher GDP growth, which would be on average 0.45 percentage point higher over 2017-2019.

Overall, the short-term effect of changing the LTV limit could have a substantial effect on the economy. The effect would be significantly higher compared to the effects of introducing the LTV limit (analyse in 4.2 section), as the existing LTV limit is binding for more borrowers. Moreover, we show that the effects of loosening or tightening the LTV limit differ and are not symmetric. The effects presented here would not be achievable with capital instruments under any reasonable assumptions.
Figure 9: Impact of hypothetical scenario: changing the LTV limit at the end of 2016
Note: Solid black line denotes the actual relevant series (from 2016Q1 it is forecast by our BVAR model). Green dotted line denotes the counterfactual scenario if the LTV limit had loosened to 95%. Red dotted line denotes the counterfactual scenario if the LTV limit had tightened to 75%.

Table 2: Counterfactual simulations of the effects of introducing the LTV limit at the end of 2016

<table>
<thead>
<tr>
<th></th>
<th>Looseing of LTV limit to 95%</th>
<th>No policy change</th>
<th>Tightening LTV limit to 75%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH credit growth (%)</td>
<td>Real GDP growth (%)</td>
<td>Housing price growth (%)</td>
</tr>
<tr>
<td>2017</td>
<td>6.7%</td>
<td>4.0% (+0.18 pp)</td>
<td>7.3% (+0.5 pp)</td>
</tr>
<tr>
<td>2018</td>
<td>10.1% 2.9% (+0.41 pp)</td>
<td>7.2% (+1.0 pp)</td>
<td>7.0% 2.5% 6.2%</td>
</tr>
<tr>
<td>2019</td>
<td>12.3% 3.0% (+0.53 pp)</td>
<td>7.1% (+1.5 pp)</td>
<td>7.1% 2.8% 5.5%</td>
</tr>
<tr>
<td>Cumulative (2017-2019)</td>
<td>34.5% 16.6% (+1.42 pp)</td>
<td>23.2% (+3.4 pp)</td>
<td>23.1% 9.4% 19.7%</td>
</tr>
</tbody>
</table>

Note: the numbers in table denote the YoY percentage growth; in brackets, we provide differences with the "no policy action" scenario. f denotes forecast, pp denotes percentage point.

4.4 Assessing if the introduction of the LTV limit would have helped to mitigate the 2005-2008 credit boom

The Lithuanian economy was among those hardest hit by the global financial crisis that erupted in 2008. This can be explained not just by deteriorating external conditions, but also by internal imbalances. The credit and housing price boom was especially strong during the economic upturn in 2005-2008, which led to severe overheating pressures. For most of the decade, Lithuania enjoyed a very strong economic boom: in the period 2000-2007, its nominal GDP grew on average by almost 8%, while its MFI loans portfolio grew on average more than 60%. Thus, credit-fueled domestic demand and a growing housing sector provided a powerful stimulus for overall economic activity during the boom years. However, in the second half of 2008, economic activity suddenly slowed down, and in 2009 the economy experienced a 15% contraction, followed by seven-year deleveraging phase. For a more detailed review of boom and bust cycles, see Ramanauskas (2011).

During the economic upturn, there were no macroprudential instruments in place.

In this section, we do a counterfactual analysis of how credit, GDP and housing prices would differ if the LTV limit of 85% had been enacted at the end of 2004. If such a policy measure had been introduced, it would have affected about 40% of mortgages over 2005-2008. In Fig. 10, we show how an LTV limit of 85% would have affected the whole market LTV distribution.
Figure 10: Hypothetical introduction of LTV limit at the end of 2004

Over four years (see Fig 10a), about 40 percent of borrowers were getting loans with higher than 85% LTV ratio. This means that the introduction of an LTV limit would have affected those borrowers. Some of those constrained borrowers would not have been able to take a mortgage, as they would not have had the newly required initial deposit. The introduction of the LTV limit at the end of 2004 would have eliminated approximately 15% of new borrowers over the analysed period (2004-2008) (see Fig 10b). Others would have been forced to take loans with lower LTV ratios. This would have had affected the mortgage flow and the overall portfolio of MFI loans to households (see Fig. 11). This would have decreased flow on average around 23%, and the policy measure would have become more restrictive during 2006-2007 as credit standards were becoming more loose.

Lower new mortgage issuance would have accumulated to a significant effect on overall credit to households, which would have been about 21% lower after four years. We should take into account that the mortgage portfolio started to grow from relatively small initial values; consequently, the growth rate was extremely high during the credit boom (2004-2008). Annual household credit grew on average by 58% and over this period increased more than 5 times. In part, this was driven by financial deepening; however, part of it should be attributed to formation of the housing bubble.

Lower mortgage credit growth would have had an impact on housing prices and economic activity. The introduction of the LTV limit would have lowered house price growth (by on average 3.1 percentage point per year) and substantially lowered real GDP growth (on average by 1 percentage point per year). Nevertheless, cumulatively, this would have had considerable effects: after four years, it would have led to a 21% lower house price index and a 4.4% lower real GDP. Quantitative results are provided in Table 3.

All in all, we show that the introduction of an LTV limit of 85% would have helped to mitigate the credit and housing booms. Such a limit would have helped to lower the mortgage credit by about 1.88 bn. Eur. (HH credit would have been 21.6% lower compared to actual data). Lower credit growth would have helped to mitigate the housing price, making it 8.7% lower in 2008.
Figure 11: Impact of hypothetical scenario: changing the LTV limit at the end of 2004

Note: Solid red line denotes the actual relevant series. The dotted black line denotes the counterfactual scenario if
the LTV limit had been introduced at the end of 2004.

Table 3: Assessment of the impact of introducing the LTV limit

<table>
<thead>
<tr>
<th>Actual</th>
<th>Counterfactual (if the LTV limit of 85% had been introduced in the end of 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH credit stock (Bn. Eur)</td>
</tr>
<tr>
<td>2005</td>
<td>2.7</td>
</tr>
<tr>
<td>2006</td>
<td>4.6</td>
</tr>
<tr>
<td>2007</td>
<td>6.6</td>
</tr>
<tr>
<td>2008</td>
<td>8.7</td>
</tr>
<tr>
<td>Cumulative</td>
<td>22</td>
</tr>
</tbody>
</table>

Note: the numbers in the table denote the YoY percentage growth; in brackets, we provide differences from the "no policy action" scenario.

5 Discussion: costs and benefits of macroprudential policies

In this paper, we use a two-step approach to quantitatively evaluate the impact of introducing (or changing) the regulatory LTV limit. However, it should be noted that we provide just an estimate of short-term cost of macroprudential policy. As we introduce a new (or tighten an existing) LTV limit, we moderate credit growth, thus lowering GDP growth. Nevertheless, by introducing additional macroprudential measures, macroprudential authorities intend to lower economic volatility: they accept short-term cost intending to lower GDP loss during the crisis. However, our approach does not allow us to directly evaluate those benefits of introducing the LTV limit.

To show how lower credit growth would have affected the depth of the economic downturn, we can rely on a simple "back of an envelope"-type calculation. Jordà et al. (2013) use a local projection method to study how past excessive credit accumulation impacts key macroeconomic variables such as output, investment, lending, interest rates, and inflation. They demonstrate that excessive credit growth leads to deeper financial crisis. They show that one can predict the depth of a crisis by excessive credit growth in the pre-crisis period. Using their estimates of how excessive credit growth affects economic downturns, we rescale our crisis GDP path to account for that.22

22Our approach in estimating how lower credit expansion during the booms phase would affect the path of downturn shares features with Svensson’s (2017) approach. However, Svensson (2017) estimate how lower credit
Conceptually, we predict the depth of the crisis using an actual excessive credit indicator, and then we predict the crisis with excessive credit, which would have been present if we had introduced an LTV limit of 85 percent in 2004. The introduction of an LTV limit affects excessive credit in a non-trivial way, as it affects credit growth (negatively), but also affects GDP growth negatively. Nevertheless, as the effect on credit growth is significantly more pronounced, the excessive credit indicator falls.

In Fig. 12, we show the counterfactual real GDP path if the LTV limit of 85% had been enacted at the end of 2004. The LTV limit would have reduced excessive credit growth and GDP growth during the economic boom. Nevertheless, it would also have reduced the GDP drop. If the LTV limit had been introduced, the real GDP drop in 2009 would have been 10.0% (instead of 14.8%). While the introduction of the LTV limit would have lowered the GDP drop, the economic downturn would still have been significant, because it was associated not just with a sharp unwinding of accumulated domestic imbalances, but also with external factors. Nevertheless, the accumulated effect of the introduction of the LTV limit in 2004 would have been around 55.8% of the 2004 GDP.

The estimates provided in this section should be seen as only indicative because they rely on a significant assumption, namely, that excessive credit is the only factor impacting the severity of an economic downturn. Nonetheless, the section shows that under somewhat reasonable assumptions, the introduction of the LTV limit before the crisis would have had a significant net benefit.

24To get ex-post counterfactual GDP estimate, we use Jordà et al.’s (2013) provided elasticities of how the GDP fall during the crisis depends on excessive lending before the crisis. In our model, we use MFI loans to households; however, in Jordà et al.’s (2013) paper, overall credit is used. Therefore, we need an assumption about how lower credit to households would have affected other loans (mainly to NFC). We assume that lower HH loan growth would have lowered the credit growth to NFC by the same portion. This assumption is based on the fact that a significant portion of NFC loans were issued to firms related to the real estate sector. Moreover, a simple correlation between HH and NFC loans are very high. During this period, we have a co-integrating relation between HH and NFC loans.

25We should note that one cannot underestimate the negative impact of the global trade crisis on Lithuanian exports and thereby on the economic activity. During the boom period, growth of real exports outpaced GDP growth. In the fourth quarter of 2008, exports started to deteriorate sharply as a result of collapsing external demand – in 2009, real exports declined by 13%, or as much as 25% in nominal terms. See Ramanauskas (2011).
6 Conclusion

In this paper, we adopt a dual micro-and-macro simulation strategy to assess the impact of introducing or changing the LTV limit. Because of the nature of borrower-based macroprudential measures, to accurately assess this impact we need to use borrower-level micro data. Tightening (or loosening) of the LTV limit raises the share of borrowers constrained by the policy measure in question; thus, the overall impact depends on initial market conditions. If not many borrowers are constrained by the increased limit, the impact will not be substantial\(^{26}\).

We quantitatively estimate that if the LTV limit had not been introduced, the household loan portfolio would have grown on average 1.5 percentage points faster (over 2012-2014). This would have led to a 0.5 percentage point higher housing price growth and a 0.2 percentage point higher real GDP growth. The introduction of the LTV limit in 2011 had a modest immediate effect, as the credit growth at the time was low, credit standards were tight and, thus, the new regulatory limit was non-binding for most borrowers. However, lowering the LTV cap at current market conditions would have a much more pronounced effect. Tightening the LTV limit to 75% in 2016 would have had a significant effect on new mortgage issuance, which would have been around 30% lower compared to the "no policy change" scenario. In this case, the portfolio of MFI loans to households would have grown 6.2% (on average 2% per year) over three years, compared to 23.1% (on average 7.2% per year) in the "no policy change" scenario. This would have translated into lower house price growth, which would be on average 1.6 percentage points lower over 2017-2019, and lower GDP growth, which would have been on average 0.7 percentage points lower compared to the "no policy change" scenario.

We also show that if the LTV limit had been implemented in 2004, it would have substantially helped in tempering the credit and housing boom. The introduction of the LTV limit would have lowered house price growth (by on average 3.1 percentage point per year) and substantially lowered real GDP growth (on average by 1 percentage point per year). Cumulatively, this would have had considerable effects; after four years, it would have led to a 21% lower house price index and a 4.4% lower real GDP. Lower accumulation of domestic imbalances would have helped to prevent such a vast economic slowdown.

Nevertheless, our micro-and-macro simulation strategy provides only an estimate of a short-term impact of the LTV limit. This could (and should) be viewed as a cost of macroprudential policy. As we do not provide an estimate of the benefits of the LTV limit, the picture drawn here must be considered only partial.

References


\(^{26}\)This means that during the economic downturn, the loosening of the LTV limit might not have been effective as a measure to stimulate the economy. We discuss the dynamics of market LTV ratios after economic shock in Annex D.


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A Behaviour function and approximation of LTV distribution

Note: In Fig. A.13a, we provide a comparison between our behaviour function (2) and the behaviour function proposed in Cussen et al. (2015). In Fig. A.13a, we provide an actual distribution of market LTV in 2012Q1 (blue bars) and an approximation of market LTV distribution using our behaviour function (2) and market LTV distribution in 2012Q2.

Figure A.13: Behaviour function and approximation of LTV distribution
B Approximating the steady state distribution of LTV ratios

We approximate the steady state distribution of LTV ratios by an average of the years 2005 to 2018 actual market distributions. This might not be fully appropriate, as in a large portion of our sample (2005Q1-2011Q3) there was no regulatory LTV limit in place, and afterwards (2011Q3-2018Q3) there was a regulatory limit of 85%, which distorted the market LTV. Nevertheless, if we did not include the part of sample in which there was an LTV limit, we would have an over-representation of the boom phase. In Fig. B.14a, we provide a comparison of steady state distributions under those two assumptions.

It is worth noting that we have to approximate the steady state market LTV distribution under various LTV limits because after the loosening of the LTV limit, the market LTV distribution would have converged to a new market LTV distribution, which would be still constrained by the LTV limit. In Fig. B.14b, we provide an approximation of a steady state market distribution constrained by an LTV limit of 85%.

Figure B.14: Distribution of LTV ratio of new mortgages before and after introduction of LTV limit

Note: The blue bar denotes the approximated steady state market LTV distribution by an average market LTV distribution during 2005-2011Q2. The green dots denote the approximated steady state market LTV distribution by an average market LTV distribution during 2005-2018Q3. The constrained distribution is approximated using an unconstrained steady state distribution and equation (2.)
C Net benefit of the introduction of the LTV limit in 2004

A common approach to measure the costs of a crisis involves summing the cumulative loss of output relative to its pre-crisis trend. As Haldane (2017) points out, it is clear that the output losses from the financial crisis, relative to pre-crisis trends, have been extremely large and long-lasting. In some cases, the losses could be permanent. Following this logic, we assume that macroprudential policies can help to avoid this permanent damage. We calculate the difference between an actual real GDP and a counterfactual one, provided in Fig. 12.

The difference is negative from 2005 to the end of 2008, as LTV dampens GDP growth during the economic downturn, and positive from 2009 (see Fig. C.15a). If we assume that this is a permanent trend shift, we can calculate the benefit of the hypothetical introduction of the LTV limit in 2004. In Fig. C.15b, we provide the cumulative effect of the introduction of the LTV limit under various discount factors. The effect of LTV introduction turns positive in 2014-2016 (depending on the assumption of a discount factor). This effect would be around 55.8%, if we assume a discount rate of 3% (213.9% under a 1% discount rate and 25.3% under a 5% discount rate).

![Graph](image)

(a) Difference between actual GDP and counterfactual scenario of LTV limit introduction  
(b) Cumulative benefit of introduction of LTV limit under different discount factors

**Figure C.15:** Comparing cost and benefits of introduction of LTV limit in 2004

It is crucial to understand that the effectiveness of the macroprudential LTV limit depends on the dynamics of the market LTV. To give a real-world analogy, the effectiveness of the road speed limit depends on the choice of driving speed of individual drivers if there were no limit. If many drivers drive particularly fast, the limit could affect a significant portion of drivers. The opposite can also be true. On a rainy day, drivers could choose to drive slower to avoid risks; thus, the speed limit is less “effective”, as it does not constrain many drivers.

A similar logic applies to the macroprudential LTV limit. If negative shocks hit the economy, banks (and households) choose to lend (borrow) with higher initial deposits and, thus, lower the LTV limit because of a perceived increase in risks. Therefore, any existing macroprudential LTV limit could become less binding over the crisis. Fig. D.16 shows the market LTV distribution of the flow of new mortgages before and after the financial crisis of 2008-2010. Before the crisis, many mortgages were issued with relatively high LTV limits (Fig. D.16a). However, this changed during and after the crisis (Fig. D.16b), as most mortgages were issued with an LTV limit of 70 percent. There was no LTV limit in place before the crisis.

A macroprudentail LTV limit of 85 percent was introduced at the end of 2011. The Covid-19 shock hit Lithuania at the end of March 2020\(^{27}\). We see that before the shock, most mortgages were issued with an LTV ratio close to the macroprudential LTV limit (Fig. D.17a). However, after the shock, most mortgages were issued with an LTV limit of 80 percent (Fig. D.17b). Thus, the COVID-2019 shock had a less pronounced effect on market LTV ratios than the financial crisis. Nevertheless, it is hard to imagine that any loosening of the existing limit during this time would have had any meaningful stimulating effect on the economy.

![Fig. D.16: Evolution of market LTV distribution over the financial crisis of 2009](image1)

![Fig. D.17: Evolution of market LTV over the COVID-2019 shock](image2)

\(^{27}\)A country-wide lockdown was introduced on the 16th of March.