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The macroeconomic effects of the regulatory LTV and LTI ratios in the Central Bank of Ireland's DSGE model

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Abstract

We use the Central Bank of Ireland's DSGE model to investigate the introduction of regulatory loan-to-value and loan-to-income ratios in the mortgage market in 2015, which form part of the Central Bank's macroprudential measures. The main finding is that while the measures dampen economic activity in the short run, they bring benefits in the medium and long run. Household leverage declines, which lowers the default rate on bank loans. The economy as a whole deleverages and foreign debt decreases significantly.

1 Introduction

In 2015 the Central Bank of Ireland introduced limits on the maximum loan-to-value (LTV) and loan-to-income (LTI) requirements for new residential mortgage lending (see Cassidy and Hallissey (2016) for details). The main objectives of these regulations are to increase the resilience of the banking and household sectors to shocks in the property market and to reduce the risk of future bank credit and house price spirals.

In 2016, the Central Bank of Ireland conducted a review of these measures. The review was tasked with examining the performance of the measures against their stated objectives since introduction, and the potential side effects of the measures.

This *Letter* examines the effects of the introduction of the LTV and LTI measures had on the Irish economy, using the Bank's Dynamic Stochastic General Equilibrium (DSGE) model. In a DSGE model, the behavior of firms and households is derived from microeconomic foundations. It explicitly takes into account expectations of households and firms about the future, which is not the case in more traditional econometric models.

These features are of crucial importance when a policy change is analyzed. A change

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in economic policy affects the expectations and behaviour of households and firms, and DSGE models can account for such changes by explicitly modeling their choices and expectations. This property makes DSGE models less subject to the Lucas' (1976) critique than econometric models consisting of reduced form behavioral relationships, and are therefore an essential tool for analyzing changes in economic policies.

Moreover, because DSGE models are general-equilibrium models, they guarantee consistency between the sectors in the economy (if one sector is borrowing, then another sector must be saving). These advantages of DSGE models compared to traditional models are the main reason why the central banks of most major economies use DSGE models for policy analysis.

While necessarily an abstract representation of reality, the model we employ here is sufficiently rich to represent the relevant characteristics of the Irish economy. Moreover, it is designed to capture both the direct effects of the introduced measures on household borrowing as well as the second-round and feedback effects on the main macroeconomic variables and the country's external position.

The main finding is that while the introduction of new measures could have some temporary contractionary effects in the short run, it leads to a significant reduction in leverage both in the short run and in the long run. This is a direct consequence of lower indebtedness of households, banks, and the economy as a whole. Because high leverage tends to exacerbate the effects of shocks, a less leveraged economy is more resilient.

2 Model summary

The current Central Bank's DSGE model of the Irish economy with the financial sector is a modified version of Clancy and Merola (2014).

The model features households, non-financial firms and banks (see Figure 1). Forward looking households earn wages from supplying labour to non-financial firms, receive interest from deposits and dividends from firms. Households optimally allocate their income between saving and consumption and their wealth between housing and physical capital, as well as saving and transaction deposits. There are no renters. Households can borrow from banks at a variable loan rate that depends on the household's expected risk of default. The lower is the housing value relative to loans, the higher is the expected probability that households default on their loans. Each quarter, a fixed fraction $(1-\rho_L)$ of loans mature, implying that the average maturity of outstanding loans is $1/(1-\rho_L)$.[2] However, loans can be repaid before maturity without cost. We calibrate $(1-\rho_L)$ to match loan-level data.[3]

The non-financial firms sector consists of a tradable goods sector, which produces export goods, and a non-tradable goods sector. Domestic consumption consists of imports and home-produced non-tradable goods. Home produced non-tradable goods are used for non-residential and housing investment.

Banks fund their lending with household deposits, foreign deposits and equity. Equity can change only through retained earnings. Banks are also subject to minimum capital regulation as in Jakab and Kumhof (2015), and returns on bank assets are affected by idiosyncratic shocks that can cause a bank to deviate from the required capital ratio. In this case, banks have to pay a regulatory penalty, which is higher when bank leverage is higher. The penalty captures the expected cost asso-

[2] This is a technical assumption simplifying aggregation in the presence of maturities exceeding one quarter.

[3] More specifically, $1-\rho = \frac{1}{Average\ maturity\ of\ mortgages\ outstanding} = 0.0156$.

ciated with the risk of falling below the required capital ratio if a bad shock occurs. To avoid the penalty, banks hold a capital buffer above the minimum regulatory requirement. When banks set the interest rate they charge for a loan, they take into account the cost of deposits, the probability that more lending increases their risk of undercapitalization and having to pay the associated penalty, and the probability of household default, which in turn depends on household leverage.

In order to capture the restraining impact of the regulation on household borrowing, we assume that the household sector has an incentive to obey the regulatory maximum, which we denote as $\overline{LTV}_t$. This incentive could reflect the desire to avoid the effort associated with applying for an exception or submitting a mortgage application which may ultimately turn out to be unsuccessful, and the fear of the legal consequences of misrepresenting the financial situation when applying for a mortgage. Furthermore, we also attempt to take into account that the regulation applies only to new loans, but not to the existing ones. We do so by assuming that the household sector cares about the weighted average difference at origination between the actual and the regulatory LTV, with the average being taken across the total stock of outstanding loans. As a consequence, the effect of regulation on overall household borrowing and expenditure comes into effect gradually following the introduction of the regulation. The effect of the LTI regulation is modeled analogously.

The model is calibrated to the Irish economy as follows. The first set of parameters that are linked to the Great Ratios (ratios of consumption, investment, exports and imports to GDP) are calibrated such that the main steady-state ratios of the model fit the historical averages over the period from 2003 to 2014. After these ratios are matched, we calibrate the parameters governing model dynamics (while not affecting the steady state) by matching the impulse-response functions of the model with the impulse-response functions from the identified empirical BVAR model estimated for Ireland.[4] In this way we ensure that the model is able to capture the main long-run features of the Irish economy as well as their short-run dynamics.

3 Simulation design

We simulate the introduction of the macroprudential regulation as a reduction in the maximum LTV ratio $\overline{LTV}_t$. The evidence from loan level data suggests that during 2015, the macroprudential measures had a somewhat more pronounced effect on the LTV distribution than on the LTI distribution of new loans (Keenan et al. (2016)). This may suggest that the LTV cap was constraining household behaviour more than the LTI cap.

We first set the initial regulatory LTV ratio, $\overline{LTV}_0$, equal to the observed pre-regulation steady state LTV ratio in the model. This is meant to capture the situation prior to the introduction of the regulation. Suppose $\overline{LTV}_{new}$ is the new regulatory LTV ratio (after the introduction of the regulation). We set $\overline{LTV}_{new} - \overline{LTV}_0$=-0.63 percentage points. This number is computed from loan level data as the difference between the median LTV at origination in 2015 and 2014 (i.e. before the introduction of the regulation).

We use the change in the median LTV at origination because this is the statistic that comes closest to the change in $\overline{LTV}_{new} - \overline{LTV}_0$ that a representative household in the model would face. The implicit simplifying assumption behind this calibration is that the 2015 decline in the LTV at origination was

[4] These include, among others, various adjustment costs and the inter temporal elasticity of substitution of households. See Lozej, Onorante, Rannenberg (2016) for details.

[5] The data used are for all borrowers, and for in-scope loans. For 2015, data are for the period after 9 February 2015, when the measures were introduced. We are grateful to Conor O'Toole of the Financial Stability Division for

driven exclusively by the introduction of the regulation.[5] Finally, note that once all loans have been rolled over, the average LTV will have declined by approximately 0.63 percentage points as well.

Although the microdata appears to suggest that the LTV component had a more constraining effect on household borrowing than the LTI component, we also investigate the alternative approach of capturing the regulation as a decline in the maximum LTI, $\overline{LTI}_t$. $\overline{LTI}_t$, where $\overline{LTI}_{new} - \overline{LTI}_0$ is calibrated in order to achieve the same effect on the average LTV as in the simulation where we reduce $\overline{LTV}_t$. It will turn out that the long and short run effects are very similar to the case where the regulation is simulated as a decline in $\overline{LTV}_t$.

4 LTV reduction

The effects of the regulatory LTV reduction on the Irish economy in the short and medium run are shown in Figure 2, while the long-run effects are reported in Table 1.

In the short and medium run (Figure 2), a reduction in the regulatory LTV ratio implies that households find themselves closer to the regulatory constraint, and therefore prioritize deleveraging over other uses for their funds. They save more by reducing consumption and investment expenditure (first row of Figure 2), which leads to an improvement in the household sectoral balance (middle panel of the last row in Figure 2). Furthermore, households post lower bids in the housing market, implying that house prices and residential investment decline.[6] The simulated effect on residential investment and house prices is in line with the empirical results of Cussen et al. (2015), who estimated the effect of the policy using a BVAR.[7] At the economy-wide level, the decline in domestic demand reduces imports and wages, implying that exports increase and the trade balance improves.

Household loans decline mainly as a consequence of the decline in household consumption and investment expenditure relative to their income. In the very short run, a reduced need for funds related to housing purchases also plays a role. As a result, total loans decrease more than total deposits (the last two panels in the third row of Figure 2). Therefore the deleveraging of households leads to an improvement of the sectoral balance of the household sector. The decline in household borrowing is reflected in a gradual decrease in the banks' foreign debt, as the funding needs of banks decline. As all borrowing from abroad is channeled through the banking sector, the economy's foreign debt declines (see the bottom-left panel in Figure 2).

The policy causes a permanent reduction in the loan interest rate. Firstly, lower household borrowing permanently reduces the share of non performing loans and thus the losses banks suffer from household default. Secondly, lower household borrowing implies that banks deleverage as well, as reflected by the increase in the bank capital ratio. A higher bank capital ratio lowers the risk of undercapitalization and the associated expected costs. Banks pass these savings to their customers in the form of a lower loan interest rate.

Furthermore, once households have deleveraged sufficiently, they can afford to increase their expenditures, allowing consumption, residential and non-residential investment to gradually recover. The lower foreign debt burden implies that, in the long run, debt

providing the data that enabled us to perform the calculation. Note that we opted for the change in the median LTV to calibrate the measure. The decline in the mean LTV amounts to 0.41 percentage points and is somewhat lower.

[6] The decline in house prices causes the value of the collateral owned by households to decrease, which results in a short-lived increase in the default probability and a temporary increase in the LTV.

[7] The authors estimate the effect of the policy

service is lower and the economy can afford a lower export surplus, which is reflected in slightly higher domestic consumption in the long run (Table 1).

The long run increase in household income net of interest payments causes a decrease in residential investment and the housing stock and a small increase in the house price (Table 1). Higher household income allows households to work fewer hours, which lowers labor supply, increases the real wage and thus makes new houses more costly to produce. At the same time, higher household income makes households post higher bids in the housing market.

Overall, even though the introduction of the LTV and LTI measures dampens the economic activity in the short run, it leads to benefits in the medium and long run. Some of those benefits - lower household debt, bankruptcy risk and borrowing rates, as well as lower foreign debt - are realised after a period of about five years, while the others take longer.

5 LTI reduction

As mentioned above, the LTI reduction is calibrated such that it achieves the same decline in the average LTV as when we simulate the LTV reduction. The outcome is shown in Figure 3. The effects are qualitatively similar to the LTV reduction. In the same way as for the LTV, a reduction in the regulatory LTI ratio increases the marginal utility of reducing household borrowing as compared to their marginal utility of consumption, housing, and the benefits from holding physical capital. Therefore, the transmission of this shock through the economy is very similar to the transmission of a reduction in the LTV. Given that the transmission channels are similar and that the magnitude of the shock in terms of lending outcomes is harmonized with the magnitude of the reduction of lending after the LTV decrease, the results are also quantitatively similar. This can clearly be seen both in Figure 3 for the short and medium-run effects and in Table 1 for the long-run effects.

6 Caveats

As with any model simulation, there are a number of caveats to the above results. First, the model most likely overstates the decline in non-residential investment shown in the figures. In the model, it is households (rather than firms) who own the non-residential capital stock. Therefore, when faced with the tightening of the regulatory constraint, one of the ways households try to reduce their borrowing is to sell their non-residential capital, which depresses non-residential investment. If goods producers were modeled as a separate sector, this direct contractionary effect on investment would have been absent since non-residential physical capital is not subject to the LTV/LTI regulation.

Second, the assumed feedback from the reduction in foreign debt to the reduction in the risk premium required for borrowing abroad is calibrated to be very small. Deleveraging of the economy therefore leads to relatively conservatively estimated benefits from the reduction in the cost of foreign borrowing. Had the feedback been calibrated to be stronger, long-run interest rates would have been lower and benefits in terms of consumption would have been higher.

Third, the negative impact on the housing stock in the long run is likely overstated. The reason for this is that it relies on the wealth effect on the labour supply and therefore on higher wages. Given the openness of the Irish labor market (see FitzGerald and Kearney, 1999), it is very likely that higher wages would lead to more immigration, which would dampen the wage increase and counter the already small wealth effect on the labour supply and on house prices. Moreover, immi-

gration would put an additional pressure on the demand for housing.

Fourth, our assumption that the loan interest rate is both variable and that it depends on the risk of default of the borrower in the following quarter is clearly an abstraction. It implies that the existence of multi-period maturities matters only to the extent that they reduce the speed at which a change in the regulatory LTV affects household behaviour. In reality, the variable rate on a multi-year mortgage taken out in the past will typically not increase if a borrower becomes more risky, although the borrower's risk would become relevant once a borrower decides to refinance. Furthermore, multi-period maturities also allow a household to fix its loan rate for a number of periods. At the same time, the early repayment of such a loan would typically involve costs. It is difficult to know a priori how exactly such features would shape the effect of LTV and LTI regulations. Finally, a more complete modeling of household default taking into account unemployment may also affect the above results.

Fifth, households in the model are all owner occupiers and do not rent. The above analysis is thus silent on any effect the macroprudential regulation might have on rents.

On balance, our conclusion from the above considerations is that the simulation is likely to overstate the short run costs and understate the long run benefits of the introduction of the regulation.

7 Related work at other policy institutions

While the literature on LTV and LTI changes from the policy perspective is relatively rare, there has been some work at the IMF and at the ECB in this direction. We briefly outline their approach and explain where and why our approach differs.

The IMF has initiated some work on LTV (see, Beneš et al., 2016) in a modeling framework that is similar to ours (the model of Clancy and Merola (2014) is based on the IMF model). In particular, in their model (and in ours) bank lending can be decoupled from the aggregate savings in the economy. The focus of the work at the IMF, however, is on the countercyclical effects of the LTV limits. They do not consider a permanent change in the regulatory LTV ratio and its effects on the long-run equilibrium. Their main finding is that using a long-run average of house prices in the regulatory definition of the LTV ratio helps to smooth financial and real cycles.

The ECB has developed the 3D model (Clerc et al., 2015) to analyse macroprudential issues, but there have been no published papers regarding the effects of LTV or LTI regulations analyzed with this model.[8] While this model is highly sophisticated, it is a closed-economy model and is therefore not able to capture several open-economy features that are important for the Irish economy, both in terms of international goods trade flows as well as cross-border financial flows.

8 Conclusion

We simulate the introduction of LTV and LTI regulation in a micro-founded model of the Irish economy. The main finding is that the introduction of regulatory ceilings on LTV and LTI ratios has somewhat contractionary effects in the short run, but leads to deleveraging of households, banks, and the economy as a whole both in the short and in the long run. In particular, households reduce their debt, which makes them less risky. This reduces the household default rate in the medium and long run.

[8] The 3D model features three layers of default (hence the name) - for households, non-financial corporations, and banks.

Because households are now less risky, lending rates decrease.

Moreover, because households borrow less, banks are less leveraged and also the economy as a whole significantly reduces its foreign debt. Savings from the reduced burden of interest payments on foreign debt create space for an increase in consumption in the long run. The model indicates that the regulatory measures do lead to a moderate decrease in housing investment and the stock of housing in the long run. However, this effect is largely offset by the increase in consumption, so that long-run effects on GDP are negligible.

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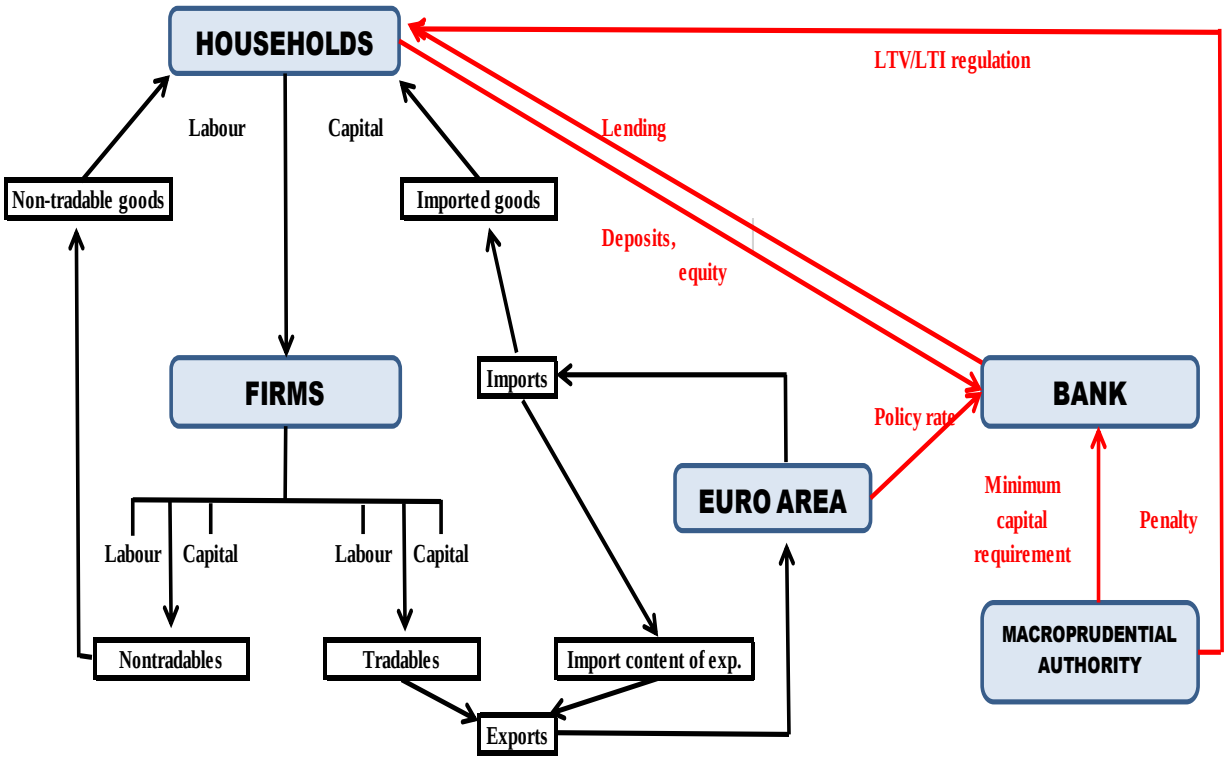
Tables and figures

Table 1: Long-run effects of LTV/LTI reduction relative to the initial steady-state

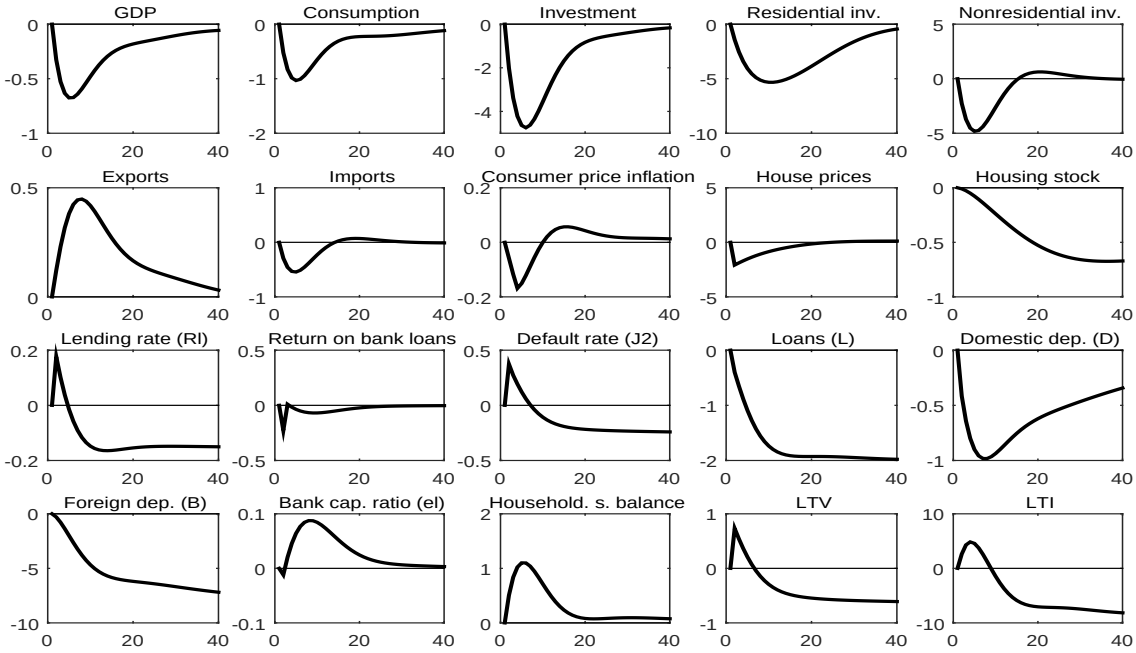
Long-run effects on variable (in %)	LTV	LTI
GDP	-0.01	-0.01
Consumption	0.09	0.07
Residential investment	-0.52	-0.29
Non-residential investment	0.16	0.01
Housing stock	-0.52	-0.29
House prices	0.12	0.04
Household borrowing	-1.86	-1.86
Foreign-debt-to-GDP ratio (in p.p.)	-1.77	-1.76
Lending rate	-0.15	-0.16
Household default rate (annualised)	-0.25	-0.27

Figure 1: Structure of the model



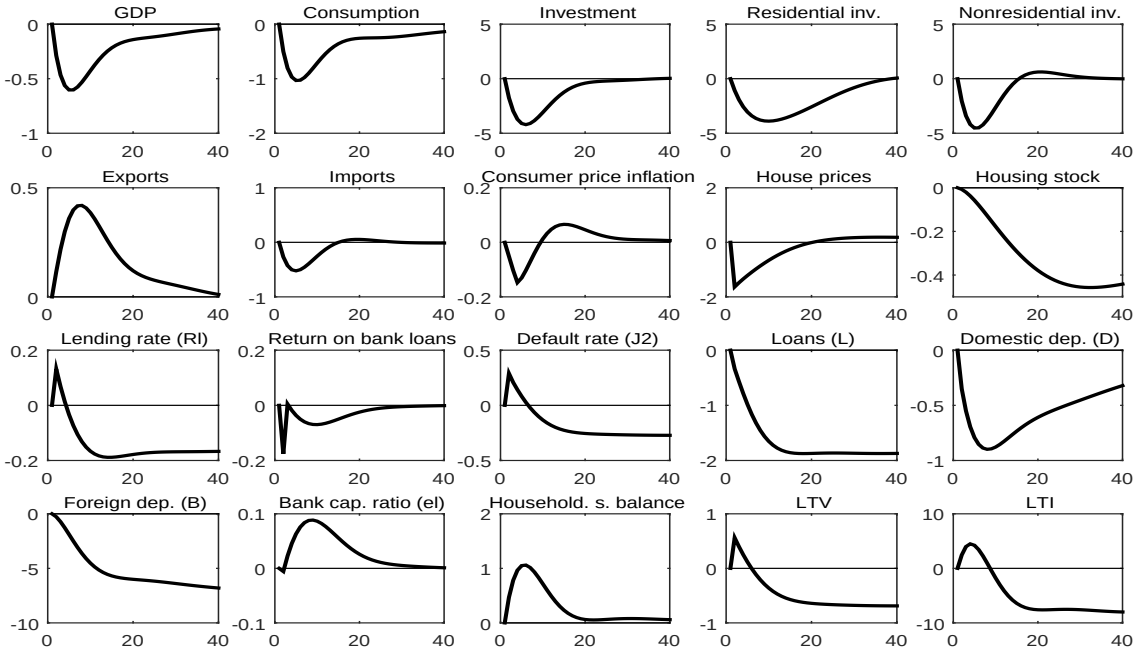
Notes: Diagrammatic representation of the structure of the model. Real parts are represented in black and financial parts in red.

Figure 2: Reduction in the LTV



Notes: Unless otherwise specified, all variables are in percent deviations from their initial values. Interest rates and default rates are in percentage-point deviations from the initial value, annualised. Household sectoral balance is expressed as the saving rate (in percent of household disposable income), and shown in percentage points as the deviation from the initial value. Bank capital ratio, LTI and LTV ratios are in percentage point deviations from their respective initial values. Units on the x-axes are quarters.

Figure 3: Reduction in the LTI



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