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Subprime borrowers, securitization and the transmission of business cycles

by

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Subprime borrowers, securitization and the transmission of business cycles *

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Abstract

One of the roots of the recent global financial crisis has been seen in the design of subprime mortgage contract leading to high sensitivity of such type of loans to house price changes. The market of subprime loans, especially in the last years preceding the crisis, has been highly financed by securitization. The paper investigates how borrowers with subprime characteristics influence the transmission mechanism of business cycles in the economy and whether the securitization of subprime loans has a positive effect on the economy. The formal setup is a DSGE model with different types of borrowers and banks acting as financial intermediaries, in which households and entrepreneurs borrow against housing collateral. The economy is subject to four shocks: monetary, inflationary, preference and technology. It is shown that the existence of subprime borrowers makes the economy more responsive to different shocks and that under certain circumstances the securitization of subprime loans (in form of residential mortgage backed securities) may lead to amplification of the business cycles.

Keywords: Subprime Borrowers, Securitization, Financial Intermediation, Great Recession
JEL-Classification: E32, E44, G01, G13, G21, R21

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1 Introduction

The 2007-2009 crisis, labeled as the Great Recession, has been the longest and the most severe post-war recession in the US. The crisis drew the attention of economists towards such subjects as bubbles, the role of financial intermediaries in the economy, as well as various aspects of mortgage markets. A common point of departure for researchers analyzing the Great Recession is the relatively small subprime mortgage market in the US that might have been one of the roots of the prolonged downturn. Globalized financial markets and mortgage derivatives enabled the spread of the domestic housing market crisis to other countries and continents. This paper investigates potential causes of the crisis in the US market. We focus on the design of subprime mortgages, their importance for business cycles, as well as the role of securitization in financing these products.

The paper presents a model in a linear Dynamic Stochastic General Equilibrium (DSGE) framework that builds on models with credit frictions, especially collateral constraints, which are discussed in the Section 1.2 Literature review. The focus is on the role of subprime mortgages and the securitization in the recent crisis. The model, which relies on empirical observations, incorporates some aspects of financial modeling into a standard macroeconomic framework, which is the main contribution of the paper. The economy is subject to four shocks: monetary, inflationary, preference, and technology. The results show that the specific design of subprime mortgage contracts, which were highly sensitive to changes in house prices, slightly amplified the US business cycle. Moreover, the securitization of subprime mortgages caused a further amplification through the balance sheet effects of the banks that were holding the securitized products. However, if the mortgage backed securities (MBS) were held by non-banks, securitization would have a positive effect of risk-spreading, leading to a smoother response of output to different shocks. Securitization itself thus cannot be blamed for the severity of the crisis. This is consistent with Jaffee et al. (2009, p.71) who conclude: *The financial crisis occurred because financial institutions did not follow the business model of securitization. Rather than acting as intermediaries by transferring the risk from mortgage lenders to capital market investors, they became the investors. They put "skin in the game".*

The results of the paper support the thesis that in principle securitization, even of the 'dangerous' subprime risk, makes sense, because different market participants have different investment horizons and may be better able to bear the credit risk than the originator. Ideally, securitized products would end up in the portfolios of such institutions as pension funds that can cushion short-term losses better than financial intermediaries. The problem occurs if financial institutions themselves engage in such transactions, because they mostly rely on short-term funding. The present model shows that if banks facing capital constraints buy MBS tranches, which lose their value in the downturn, the capital constraint gets tighter, so the whole intermediation process is disrupted and lending to other agents in economy declines, causing a credit crunch, partial termination of production and large output falls.

Although the design of subprime contract and the subprime securitization in the present model is largely based on description of Gorton (2008), his answer to the question *How could a bursting of the house price bubble result in a systemic crisis?* is slightly different from the one just provided. He argues that subprime market is a unique example in which the long chain of securities (MBS were turned into collateralized debt obligations (CDO), CDO into squared CDO etc.) and the loss of information on the investors' side led to observed big output declines. The present paper does not discuss the mechanism of the information loss, focusing on the role of financial intermediaries and balance sheet effects in the crisis.

1.1 Subprime mortgage market

In order to understand the modeling devices used in the paper, it is important to review some facts about the recent financial crisis. Figure 1 shows real US GDP growth and US house price index in years 1975-2010, with gray bars indicating NBER recessions. We see that in the case of the recent recession, the fall in house prices led the fall in GDP growth. According to the NBER, the last recession started in December 2007 (IV quarter) and ended in June 2009 (II quarter). The developments on the housing market played an important role in this crisis, similar to other recent crisis episodes in industrialized economies (Reinhart, Rogoff, 2009).

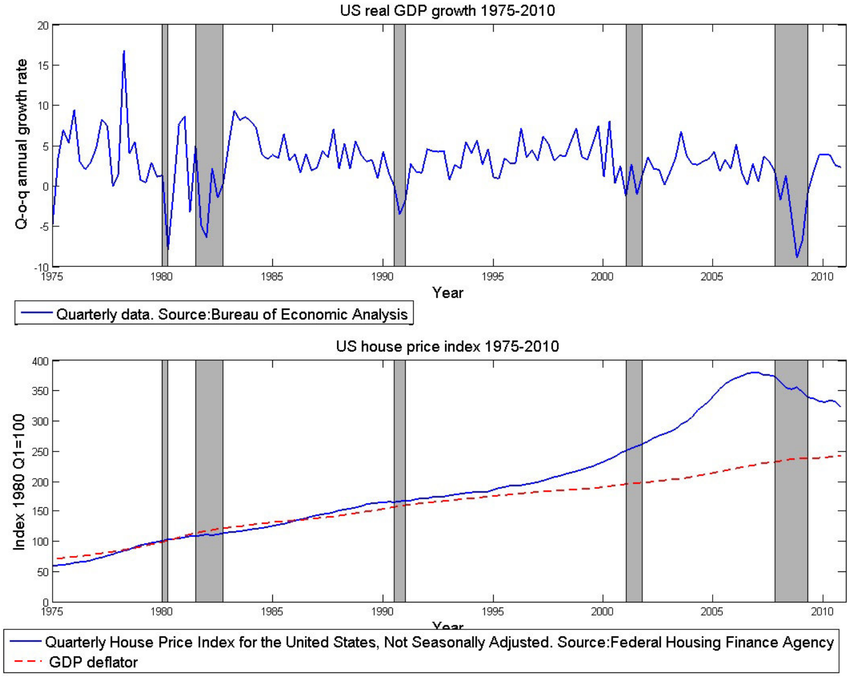

Figure 1: The evolution of GDP growth rates and house price index in the United States, 1975-2010

Source: NIPA tables 1.1.1 and 1.1.4 (GDP and GDP deflator data), Federal Housing Finance Agency USSTHPI series for the house price index.

Unlike in other countries, the fall in house prices in the US resulted in a systemic global crisis and it is important to understand how it was possible. Popular wisdom and press comments suggest that the subprime mortgage market played a substantial role in amplifying the effects of the fall in house prices, which is remarkable because it accounts for only a small percentage of the whole mortgage market. There is no exact definition of the subprime borrower or market, however, there are certain features common to all subprime loan contracts. A prime mortgage in the US is usually collateralized and has a fixed interest rate for 30 years. Subprime borrowers often can provide neither collateral, nor income (that is why they are called NINJAs - No Income, No Job or Assets). The down-payment rate in the case of prime borrowers is usually higher than in the subprime case. However, the difference is not as overwhelming as one may expect. Amromin and Paulson (2010) provide detailed data on loan to value (LTV) ratios for both groups of borrowers in years 2004-2007. In the case of prime mortgages, the average LTV ratio ranged from 74.89% to 77.75%, in the case of subprime mortgages - from 79.63% to 80.69%. The biggest difference between these two groups has been noted in the FICO score, measuring the creditworthiness of borrowers and used by lenders to determine the credit risk - in case of prime borrowers it ranged from 706 to 715, subprime - from 597 to 617 (FICO score ranges from 300 to 850, the higher, the better). Subprime borrowing was thriving thanks to a common belief that house prices will on average rise. And indeed, until the recent crisis the US market has not experienced a countrywide decrease in house prices since the 1930s.

Since subprime borrowers often do not have any assets or income, a challenge is to create a loan contract that will still enable them to pay the installments. That was made possible by creating hybrid adjustable rate mortgages of type 2/28 or 3/27, in which the first period's (2 or 3 years) interest rate was fixed and the rest (28 or 27 years respectively) varying. The shift from the fixed interest rate to the adjustable one occurred at a previously specified reset date. As Kliff and Mills (2007) note, before the outbreak of the crisis, these hybrid mortgages made up about two thirds of all ARM (adjustable rate mortgage) originations and were basically short-term fixed rate mortgages that converted into an adjustable rate mortgage after the initial period. Gorton (2008) explains how this kind of contract can be interpreted as a short-term contract. The initial interest rate depended on the loan to value ratio, which in turn depended on changes in house prices. When house prices were rising, the households were able to refinance and repay the debt and even in some cases extract equity from the homes. When house prices were falling, the LTV ratio was rising, followed by an increase in the interest rate, so that many households were not able to repay the contracted installment, or even defaulted.

Figure 2 shows the evolution of the LTV in case of a subprime contract. γ describes the probability of house price increase, $1 - \gamma$ probability that the house prices fall.

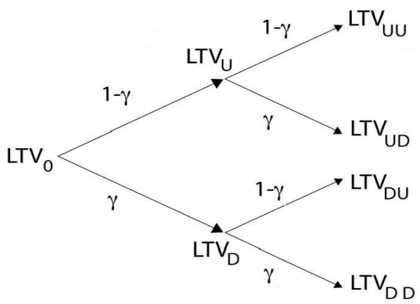

Figure 2: The evolution of house prices and the loan to value ratio

Source: Gorton (2008), p.16

The loan to value ratio moves in the opposite direction to changes in house prices. If house prices rise, the LTV ratio goes down to LTV_d, which corresponds to the borrower having positive equity in home. LTV_u corresponds to the borrower having a negative equity position in home. When house prices fall, the LTV ratio can reach very high levels, which in case of subprime mortgages meant that lenders did not refinance the loan after the initial period of fixed interest rate. Facing increasing loan payments, the subprime borrower defaulted and the bank took over the house. In fact some people live with negative home equity. However, the data shows that with falling house prices, the motivation to repay a mortgage (especially of hybrid type) falls substantially. Amromin and Paulson (2010) provide evidence of a high sensitivity of defaults to changes in home prices among subprime borrowers already in years before the crisis, compared with a very low sensitivity among prime borrowers (for 2004: -0.183 for subprime borrowers and -0.00166 for prime borrowers).

As securitization was the main financing method for subprime originations, the majority of subprime mortgages were pooled together and sold in the financial market as MBS, which were often a base for a further securitization instrument - a CDO.[1] The bonds or pass-through securities (they are called so because the monthly loan payments are passed through to the holders of security) were then sold to pension funds, investment funds and personal investors. The securitization of subprime loans might have made the whole financial system vulnerable to house prices, which is much less the case when financial intermediaries only securitize prime loans, whose value does not depend so much on the condition of the housing market. Moreover, it is important to stress that securitization is not equal to loan sales. A sold loan is no more marketable than the loan itself, whereas securitization creates a new quality through various credit enhancements.[2] Loans are being sold in a secondary market, whereas securitization creates a new primary market. That is why Gorton (2008) calls the chain of securitized subprime securities a chain of many primary markets. At the first stage, securitization is often conducted via a special purpose vehicle (SPV) that acts only for the purpose of securitization, is set up by the originator, and even does not have any employees. The securitization process includes repackaging many assets, also car or student loans into derivative securities consisting usually of three tranches: senior, mezzanine and equity, with the latter being the most risky one. The residential mortgage backed securities (RMBS) played the biggest role in the securitization market just before and after the recent financial crisis. Along with the development of the securitization markets, the number of subprime mortgages that were taken out in the decade preceding the recent crisis rose from 7 to around 20 percent of all new originations ("2007 Annual Report"). Consequently, in our model, we concentrate on the RMBS and calibrate the share of subprime borrowers to match the data. The specific design of SPVs enables me to model the securitization process without introducing a new agent into the model economy.

1.2 Literature review

There is a vast macro literature concerning financial constraints and their effects on the economy. The model presented below is based on Iacoviello (2005), which in turn relies heavily on the seminal paper by Kiyotaki and Moore (1997). Kiyotaki and Moore develop a model in which capital serves both as a production factor and as collateral for loans. Due to imperfect enforcement of lenders' rights, who have a higher discount factor than borrowers and thus provide loans to other agents in the economy, the value of loans is restricted to a certain percentage of collateral. This collateral constraint leads to the amplification and a higher persistence of shocks.

Iacoviello (2005) presents a New-Keynesian DSGE model incorporating borrowing constraints and borrowers and lenders differing in their value of impatience. The housing stock may be used as collateral by both households and entrepreneurs, for whom housing is also a production factor. If borrowers repudiate their debt obligations, lenders can repossess the borrowers' assets by paying a proportional transaction cost, equal to $(1-m)$ times the present value of the asset. Thus, lenders will make the amount of loans depend on the parameter m, which is the LTV ratio. Households have different LTV ratios than entrepreneurs, which reflects the different riskiness of loans to the two types of agents. Iacoviello shows that under certain conditions, the borrowing constraint will be binding near the steady state, both for entrepreneurs and for impatient households. In his model, borrowers take out nominal loans which leads to debt deflation effects in the

[1] The ratio of securitized subprime/Alt-A mortgages rose from 46% in 2001 to 93% in 2007 (Geithner, 2011, p.11).

[2] Credit enhancement includes: tranching of the risk of loss, over-collateralization, guarantee by an insurance company. Discussed further in Gorton, Souleles (2007).

economy. He incorporates four shocks into the model: monetary, inflationary, technology and preference. Collateral effects are shown to amplify the responses of output to different shocks, nominal debt feature improves the fit of the model to the data and introduces interesting inflationary effects.

Iacoviello (2013) has a similar setup to the benchmark 2005 model. However, in this model inflation and central bank are absent. Iacoviello introduces financial intermediaries, which can be interpreted as banks. They face capital constraints which lead to the amplification of financial shocks in the economy. The exogenous shock is triggered by a small sector of the economy (in this case impatient households, which are labeled subprimers) that defaults on its loans, which forces banks to recapitalize or deleverage and leads to a credit crunch. The credit constraint of the banks gives rise to a spread between the deposit and the loan rate. The paper allows for the existence of financial intermediaries absent in his 2005 model. Compared to the model without banks, the existence of banks in the economy amplifies the financial shock considerably. The crucial difference between the two models is the capital requirement faced by banks.

With respect to the securitization, there are only few papers in the area of theoretical macroeconomics that try to incorporate a secondary market into the analysis. One example is Faia (2011) in which a standard New-Keynesian DSGE model is combined with secondary market based on Parlour and Plantin (2008), who in turn base their model on the work of Holmstrom and Tirole (1997). Faia concludes that the existence of secondary markets amplifies the dynamics of macro variables. Compared to the presented model, Faia's model operates in a corporate market world without the housing market. Moreover, she models the secondary market for loans, not the securitization process. Another attempt to model securitization in the macro literature has been made by Hobijn and Ravenna (2010) who model securitization in a setup with banks that have access to the information about the credit score of the lenders. In the steady state, securitization leads to a decline in interest rates that especially benefits subprime borrowers. In the case of a shock, the reaction of financial variables such as interest rate spreads is amplified in comparison to a standard New Keynesian model.

While theoretical research on the effects of securitization in a macro framework is scarce, the empirical evidence on the recent crisis delivers many insights. The present paper mainly relies on a comprehensive study of Gorton (2008) describing in detail the subprime mortgage market in the US and the securitization of subprime mortgages. Another important reference is Gorton and Souleles (2007) who describe the basics of securitization process. Hellwig (2008) also delivers an extensive descriptive analysis of the events leading to the Great Recession. For the empirical facts, Kiff and Mills (2007), Amromin and Paulson (2010) as well as Demyanyk and Van Hemert (2011) are reliable sources. Temkin et al. (2002) provide a good summary of the regulatory changes that enabled the development of the subprime mortgage market in the US.

2 The benchmark model

The model economy is inhabited by a continuum of households that differ in the degree of their impatience. All households offer labor services to entrepreneurs producing intermediate output. Households consume final goods and derive utility from housing services. Patient households save in the form of deposits kept at commercial banks that grant loans to entrepreneurs and impatient prime borrowers against housing collateral. Impatient subprime borrowers borrow from a subprime lender whose liabilities are loans from the commercial bank. Banks differentiate between borrowers. Loans granted to prime borrowers have longer maturity, whereas subprime borrowers have only access to short-term contracts, which makes their repayments sensitive to changes in house prices. The financial connections of the agents are shown in Figure 3. There is a central bank in the economy implementing a Taylor rule and choosing the interest rate on deposits. Retailers, who produce a final good out of the intermediary good, are the source of nominal stickiness in the economy.

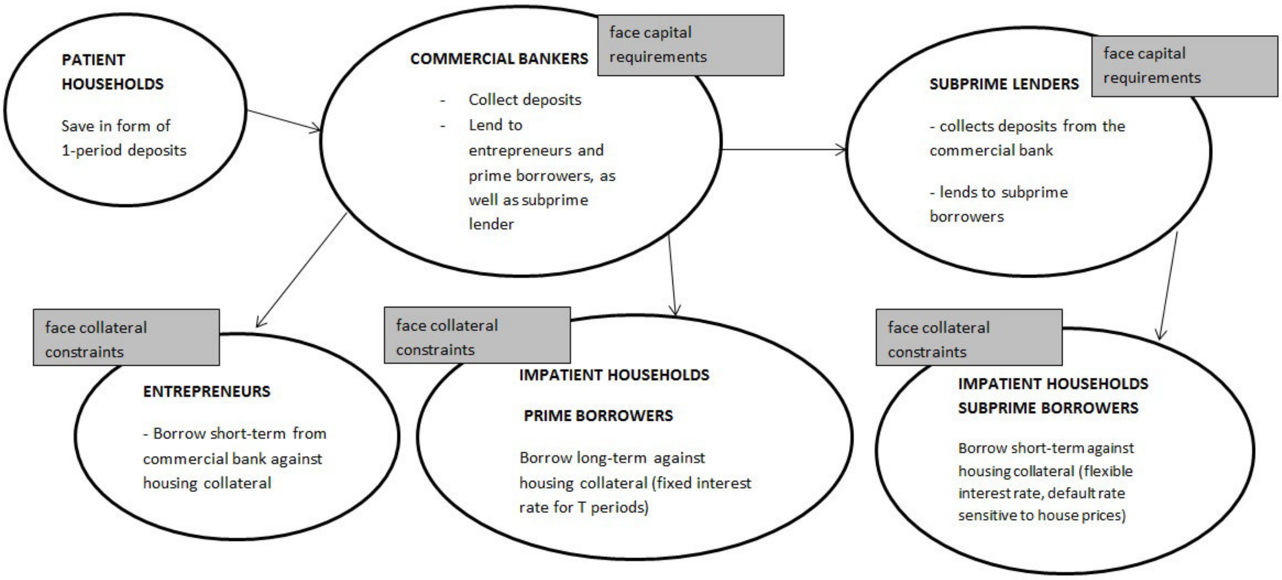

Figure 3: Financial contracts in the benchmark model

2.1 Patient households - savers

2.2 Patient households

The problem of patient households ('patients') is identical to the one in Iacoviello (2005) with one difference. Instead of providing loans to prime households and entrepreneurs, patients save in the form of deposits held at banks. Patient households consume, work and accumulate housing. They maximize the utility function given by (small letters denote real variables):

$$\max_{b'_t, h'_t, L'_t} E_0 \sum_{t=0}^{\infty} \beta^t (\log c'_t + j_t \log h'_t - \frac{L'^{\eta'}_t}{\eta'}), \tag{1}$$

where c'_t - consumption of the final good, j_t - marginal utility of housing subject to random disturbances (following Iacoviello, the disturbance is common to patient and impatient households and is a proxy for a housing demand or housing preference shock), h'_t - housing stock held by patients, L'_t - labor supply of patient households.

The budget constraint of the patient household in real terms is:

$$c'_t + q_t(h'_t - h'_{t-1}) + d_t = R_{d,t-1} d_{t-1}/\pi_t + w'_t L'_t + F_t, \tag{2}$$

where d_t - deposits, $R_{d,t}$ - interest rate paid on deposits, F_t - profits from retailers (redistributed only to patient households), $w'_t L'_t$ - labor income, $q_t = Q_t/P_t$ - real housing price, $\pi_t = P_t/P_{t-1}$ - inflation.

The First Order Conditions (FOCs) are:

w.r.t. d_t

$$\frac{1}{c'_t} = \beta E_t(\frac{1}{c'_{t+1}\pi_{t+1}}) R_{d,t}, \tag{3}$$

w.r.t. h'_t

$$\frac{q_t}{c'_t} = \beta E_t(\frac{q_{t+1}}{c'_{t+1}}) + \frac{j_t}{h'_t}, \tag{4}$$

w.r.t. L'_t

$$w'_t = L'^{\eta'-1}_t c'_t. \tag{5}$$

2.3 Impatient households - primes

Impatient prime households ('primes') buy consumption goods and housing stock and borrow against housing collateral. They have the following utility function:

$$\max_{b''_t, h''_t, L''_t} E_0 \sum_{t=0}^{\infty} \beta''^t (\log c''_t + j_t \log h''_t - \frac{L''^{\eta''}_t}{\eta''}) \tag{6}$$

The setup differs from Iacoviello's version, because it is assumed that impatient prime households have access to more than one-period loans.[3] Their borrowing in period t depends on the expected value of housing in period t+T and the amount of outstanding debt. Figure 4 shows an example of loan installments in this setup for T=2, two-period contracts (in nominal terms). Total interest cost is due in equal fractions in every period (as in Monacelli et al. (2011)). This assumption aims to capture the characteristics of a prime mortgage contract in the US, which is characterized by a fixed interest rate over a longer time period. It also distinguishes prime borrowers from subprime who have only access to short-term, one-period loans.

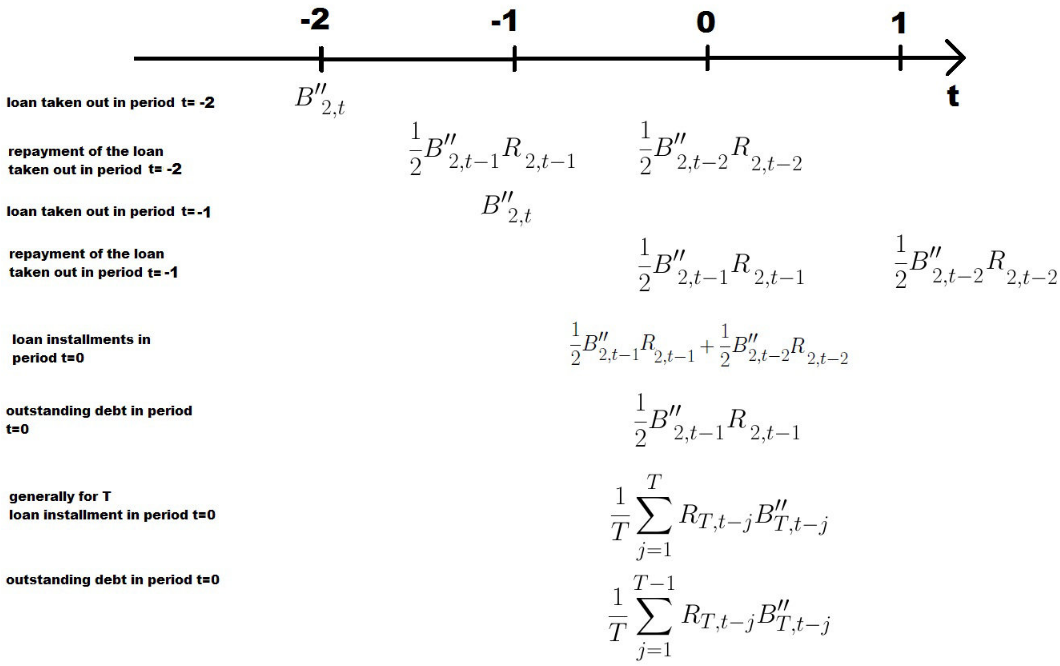

Figure 4: Installment payments of prime borrower in case of two-period contracts (in nominal terms)

The budget constraint of the impatient prime household is (in real terms):

[3] This issue has been addressed by Monacelli et al. (2011) who show that the variable-rate mortgage structure magnifies the responses of consumption and residential investment to monetary policy shock, whereas a contract in which the rate is fixed for T=2 periods dampens the impulse response of considered variables. Unlike in Monacelli et al., in the present model borrowing in each period depends not only on the future value of house prices, but also on the outstanding debt from previous periods.

$$c''_t + q_t(h''_t - h''_{t-1}) + 1/T \sum_{j=1}^{T} \frac{R_{T,t-j} b''_{T,t-j}}{\prod_{i=0}^{j-1} \pi_{t-i}} = b''_{T,t} + w''_t L''_t, \tag{7}$$

where $b''_{T,t}$ (further replaced by b''_t) is a loan contract with maturity T purchased at time t, $R_{T,t}$ - prime interest rate for a loan contract with maturity T purchased at time t (further replaced by R_t).

Notice that primes have a different discount factor than patients, while it is assumed that $\beta'' < \beta$. Impatients face a collateral constraint:

$$R_{T,t} b''_{T,t} \leq m'' E_t(q_{t+T}) h''_{t+T-1} \prod_{j=1}^{T} \pi_{t+j} - 1/T \sum_{j=1}^{T-1} \frac{R_{T,t-j} b''_{T,t-j}}{\prod_{i=0}^{j-1} \pi_{t-i}}, \tag{8}$$

where m'' is the LTV ratio. Their new debt and outstanding debt may not exceed the future value of their housing stock.

The constraint is assumed to be always binding (as in Iacoviello (2005)). Note that borrowers in the model repay the nominal amount of debt - a feature that resembles the loan contract structure in many low-inflation countries. The consequences of the nominal debt assumption have been discussed in length in Iacoviello. In short, nominal debt assumption adds debt deflation effect to the model. As borrowers have higher propensity to consume, high inflation is beneficial for output because wealth is transferred from lenders to borrowers. In case of deflation, nominal debt has a negative effect on output.

The FOCs are (λ''_t is the Lagrangian multiplier on the borrowing constraint):
w.r.t. b''_t

$$\frac{1}{c''_t} = E_t(1/T \sum_{j=1}^{T} \beta''^j \frac{R_{T,t}}{c''_{t+j} \prod_{i=0}^{j-1} \pi_{t+1-i}}) + \lambda''_t R_{T,t} + E_t(1/T \sum_{j=1}^{T-1} \lambda''_{t+j} \beta''^j \frac{R_{T,t}}{\prod_{i=0}^{j-1} \pi_{t+1-i}}), \tag{9}$$

w.r.t. h''_t

$$\frac{q_t}{c''_t} = E_t(\beta'' \frac{q_{t+1}}{c''_{t+1}} + \beta''^{1-T} \lambda''_{t+1-T} m'' q_{t+1} \prod_{i=0}^{T-1} \pi_{t+1-i}) + \frac{j_t}{h''_t}, \tag{10}$$

w.r.t. L''_t

$$w''_t = L''^{\eta''-1}_t c''_t, \tag{11}$$

w.r.t.λ''_t

$$R_t b''_t = m'' E_t(q_{t+1} \prod_{j=1}^{T} \pi_{t+j}) h''_t - 1/T \sum_{j=1}^{T-1} \frac{R_{T,t-j} b''_{T,t-j}}{\prod_{i=0}^{j-1} \pi_{t-i}}. \tag{12}$$

2.4 Impatient households - subprimers

A novelty in the model is the introduction of subprime households ('subprimers') who differ from impatient prime households in three aspects. Their loan to value ratio is slightly higher than that of prime borrowers (as in the data), they may default on their loan obligation, with the default rate sensitive to house prices, and they have only access to short-term, one-period loans, which accentuates the difference between fixed-rate prime contracts (granted mainly to prime borrowers) and variable-rate subprime contracts observed in the data. The default feature resembles a repayment shock modeled by Iacoviello (2013). However, while in Iacoviello (2013) the repayment shock is an exogenous event, in the presented model it is explicitly defined as a default rate depending on house prices.

When there is no change in the house prices, the default rate remains at its steady state level, otherwise it varies along with varying house prices.

Impatient subprime households have the following utility function:

$$\max_{b_t''',h_t''',L_t'''} E_0 \sum_{t=0}^{\infty} \beta'''^t (\log c_t''' + j_t \log h_t''' - \frac{L_t'''^{\eta'''}}{\eta'''}). \tag{13}$$

The budget constraint of the impatient subprime household looks is:

$$c_t''' + q_t(h_t''' - h_{t-1}''') + (1-\delta_{s,t})R_{s,t-1}b_{t-1}'''/\pi_t = b_t''' + w_t'''L_t''', \tag{14}$$

where $R_{s,t}$ is the nominal interest rate on subprime loans, $\delta_{s,t} = \delta_s - \phi_{s,h}(q_t - Q)$ (δ_s denotes the steady state value of default rate, Q - steady state value of house price, $\phi_{s,h}$ - subprimers' default sensitivity to house price changes) is the default rate on loans. The dependence on house prices is chosen to capture the high sensitivity of the subprime mortgage contract to house price changes and its gamble characteristics. Subprimers enter a gamble with the bank. If house prices fall, their default rate (which is positive in steady state) will increase and they will repay less than contracted (because of the negative home equity and falling motivation to repay the loan). If house prices rise substantially, they agree to pay back the loan faster than agreed, because it is theoretically possible that the increase in house prices is so big that the subprimers' default rate turns negative. However, in the chosen calibration and in the neighborhood of the steady state, the default rate always remains positive. One would need a very large house price increase to make the default rate negative. Since the model is solved using log-linearization around the steady state, only small deviations from the steady state are considered and the default rate remains positive. The default rate is not modeled as an exogenous process, because in the version of the model with securitization we want the default risk to be incorporated in the pricing of MBS structures. If default were exogenous, the mean of the shock would be zero and the risk would not be correctly priced under the chosen solution method.

Subprime borrowers are assumed to have the same discount factor as prime borrowers: $\beta''' = \beta'' < \beta$. They also face a collateral constraint:

$$R_{s,t}b_t''' \leq m'''E_t(q_{t+1}\pi_{t+1})h_t'''. \tag{15}$$

The FOCs are (λ_t''' is the Lagrangian multiplier on the borrowing constraint):
w.r.t. b_t'''

$$\frac{1}{c_t'''} = \beta'''E_t(\frac{(1-\delta_{s,t})R_{s,t}}{c_{t+1}'''\pi_{t+1}}) + \lambda_t'''R_{s,t}, \tag{16}$$

w.r.t. h_t'''

$$\frac{q_t}{c_t'''} = \beta'''E_t(\frac{q_{t+1}}{c_{t+1}'''} + \lambda_t'''m'''q_{t+1}\pi_{t+1}) + \frac{j_t}{h_t'''}, \tag{17}$$

w.r.t. L_t'''

$$w_t''' = L_t'''^{\eta'''-1}c_t''', \tag{18}$$

w.r.t.λ_t'''

$$R_{s,t}b_t''' = m'''E_t(q_{t+1}\pi_{t+1})h_t'''. \tag{19}$$

2.5 Entrepreneurs

The problem of entrepreneurs is identical to that in Iacoviello (2005). They produce intermediate output priced at P_t^w, using housing stock, capital and labor provided by households. They borrow short-term to cover their expenditures, facing a collateral constraint analogous to the one faced by households.

Their utility function is:

$$\max_{b_{e,t},I_t,K_t,h_{e,t},L'_t,L''_t,L'''_t} E_0 \sum_{t=0}^{\infty} \gamma^t \ln(c_{e,t}), \tag{20}$$

where $b_{e,t}$ - borrowings, I_t - investment, K_t - capital, $h_{e,t}$ - housing stock, L_t - labor of households, $c_{e,t}$ - consumption.

The production function is:

$$Y_t = A_t K_{t-1}^{\mu} h_{e,t-1}^{\nu} L_t'^{\alpha(1-\mu-\nu)} L_t''^{(1-\alpha)(1-\mu-\nu)(1-s)} L_t'''^{(1-\alpha)s(1-\mu-\nu)}, \tag{21}$$

where A_t is a random variable capturing technology shock process, μ and ν denote respectively capital and housing share in the production function, parameter α controls for patient households' labor share in the production function, and s controls for subprimers' share in the labor supply of households-borrowers.

Entrepreneurs' budget constraint is:

$$\frac{Y_t}{X_t} + b_{e,t} = c_{e,t} + q_t(h_{e,t} - h_{e,t-1}) + \frac{R_{e,t-1}}{\pi_t} b_{e,t-1} + w'_t L'_t + w''_t L''_t + w'''_t L'''_t + I_t + \xi_{K,t}, \tag{22}$$

where $R_{e,t-1}$ is the nominal interest rate on loans between period t-1 and t, X_t is the markup of final over intermediate goods, and the last two terms - capital adjustment and housing adjustment costs.

Investment is defined by:

$$I_t = K_t - (1-\delta)K_{t-1}, \tag{23}$$

where δ denotes the depreciation rate of capital.

The adjustment cost function is given by:

$$\xi_{K,t} = \frac{\psi_K}{2\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1}. \tag{24}$$

Entrepreneurs face a borrowing constraint:

$$R_{e,t} b_{e,t} \le m E_t(q_{t+1} h_{e,t} \pi_{t+1}). \tag{25}$$

The FOCs of the entrepreneur are (denote by u_t the Lagrangian multiplier on the investment constraint and by $\lambda_{e,t}$ - on the borrowing constraint):

w.r.t $b_{e,t}$

$$\frac{1}{c_{e,t}} = \gamma E_t\left(\frac{R_{e,t}}{c_{e,t+1}\pi_{t+1}}\right) + \lambda_{e,t} R_{e,t}, \tag{26}$$

w.r.t. $h_{e,t}$

$$\frac{q_t}{c_{e,t}} = E_t\left[\frac{\gamma}{c_{e,t+1}}\left(\nu \frac{Y_{t+1}}{X_{t+1} h_{e,t}} + q_{t+1}\right) + \lambda''_t m q_{t+1} \pi_{t+1}\right], \tag{27}$$

w.r.t I_t

$$u_t = \frac{1}{c_{e,t}}\left(1 + \frac{\psi_k}{\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)\right), \tag{28}$$

w.r.t K_t

$$u_t = \gamma E_t[(\frac{Y_{t+1}\mu}{X_{t+1}K_t c_{e,t+1}} + u_{t+1}(1-\delta)] + \gamma E_t[\frac{1}{c_{e,t+1}}\frac{\psi_k}{\delta}(\frac{I_{t+1}}{K_t} - \delta)\frac{I_{t+1}}{K_t} - \frac{\psi_k}{2\delta}(\frac{I_{t+1}}{K_t} - \delta)^2))], \quad (29)$$

w.r.t. labor:

$$w'_t = \frac{\alpha(1-\mu-\nu)Y_t}{X_t L'_t}, \quad (30)$$

$$w''_t = \frac{(1-\alpha)(1-\mu-\nu)(1-s)Y_t}{X_t L''_t}, \quad (31)$$

$$w'''_t = \frac{(1-\alpha)(1-\mu-\nu)sY_t}{X_t L'''_t}. \quad (32)$$

2.6 Retailers

The problem of retailers is identical to that in Iacoviello (2005). They are the source of price stickiness in the economy. Retailers acquire intermediate goods produced by the entrepreneurs at price ${P_t}^w$, then differentiate them into $Y_t(z)$ (retailers of mass 1 are indexed by z) and sell at price $P_t(z)$. The aggregate output index is given by:

$$Y_t^f = (\int_0^1 Y_t(z)^{\frac{\varepsilon-1}{\varepsilon}}\, \mathrm{d}z)^{\frac{\varepsilon}{\varepsilon-1}}, \quad (33)$$

where $\varepsilon > 1$. The price index is given by:

$$P_t = (\int_0^1 P_t(z)^{1-\varepsilon}\, \mathrm{d}z)^{\frac{1}{1-\varepsilon}} \quad (34)$$

.

Retailers can change their sale price every period with probability $1-\theta$. Fraction θ stays unchanged every period. Denote by $P_t^*(z)$ the reset price of the retailer and with $Y_{t+k}^*(z) = (\frac{P_t^*(z)}{P_{t+k}})^{-\varepsilon}Y_{t+k}$ the corresponding demand.

The retailer maximizes following equation:

$$\sum_{k=0}^{\infty}\theta^k E_t\Big\{\Lambda_{t,k}(\frac{P_t^*(z)}{P_{t+k}} - \frac{X}{X_{t+k}})Y_{t+k}^*(z)\Big\}, \quad (35)$$

where $\Lambda_{t,k} = \beta^k(\frac{c'_t}{c'_{t+k}})$ is the patient household relevant discount factor, $X_t = \frac{P_t}{P_t^w}$ is the markup of final over intermediate goods.

The aggregate price level evolution is given by:

$$P_t = (\theta P_{t-1}^{1-\varepsilon} + (1-\theta)(P_t^*)^{1-\varepsilon})^{\frac{1}{1-\varepsilon}}. \quad (36)$$

Combining the last two equations and log-linearizing gives us a forward-looking Phillips curve

$$\hat{\pi}_t = \beta E_t \hat{\pi_{t+1}} - \kappa\hat{X}_t, \quad (37)$$

where $\kappa \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$ and hatted variables denote percent changes from the steady state.

2.7 Bankers

2.7.1 Commercial bankers

Commercial bankers collect deposits from patient households and issue loans to prime borrowers and entrepreneurs. They also provide interbank loans for subprime lenders that also operate as a bank.[4] Commercial bankers maximize utility from their consumption (as in Iacoviello (2013)):

$$\max_{c_{b,t}} E_0 \sum_{t=0}^{\infty} \beta_b^t (\log c_{b,t}), \tag{38}$$

where β_b is assumed to be lower than the discount factor of patient households (necessary condition for the capital constraint to be binding - see Iacoviello (2013)).

The budget constraint of bankers is:

$$c_{b,t} + \frac{R_{d,t-1}d_{t-1}}{\pi_t} + b''_t + bb_t + b_{e,t} = d_t + \frac{R_{b,t-1}bb_{t-1}}{\pi_t} + \frac{1}{T}\sum_{j=1}^{T} \frac{R_{T,t-j}b''_{T,t-j}}{\prod_{i=0}^{j-1}\pi_{t-i}} + \frac{R_{e,t-1}b_{e,t-1}}{\pi_t}, \tag{39}$$

where bb_t denotes interbank lending and $R_{b,t}$ - interbank interest rate.

Banker's balance sheet looks as follows:

Assets	Liabilities
Loans to prime borrowers: b''_t	Deposits d_t
Interbank loans: bb_t	Equity eq_t
Loans to entrepreneurs: $b_{e,t}$	

Thus a Basel-type capital constraint, given exogenously, has the form:

$$\tau \leq \frac{b''_t + bb_t + b_{e,t} - d_t}{\chi_3 bb_t + \chi_1 b''_t + \chi_2 b_{e,t}}, \tag{40}$$

where $\chi_3 < \chi_1 < \chi_2$ are risk weights of assets and τ denotes an equity ratio set by a regulator.[5] The condition states that the ratio of equity (defined as asset minus deposits) to risk weighted assets has to exceed some exogenously chosen number.

The FOCs of the bankers' problem determine the interest rates paid on deposits and different types of loans (G_t denotes Lagrangian multiplier on the capital constraint):

w.r.t. b''_t

$$\frac{1}{c_{b,t}} = E_t(1/T \sum_{j=1}^{T} {\beta_b}^j \frac{R_{T,t}}{c''_{b,t+j}\prod_{i=0}^{j-1}\pi_{t+1-i}}) + (1-\tau\chi_1)G_t, \tag{41}$$

w.r.t. bb_t

$$\frac{1}{c_{b,t}} = \beta_b E_t(\frac{R_{b,t}}{c_{b,t+1}\pi_{t+1}}) + (1-\tau\chi_3)G_t, \tag{42}$$

[4]The distinction between commercial and subprime bankers is not necessary for the benchmark version of the model, but becomes important when we introduce securitization into the model economy. The evidence from the US suggests that there were several banks and financial intermediaries that specialized specifically on the subprime market.

[5]The risk weight for commercial loans secured by real estate is usually higher than for private mortgages. The risk weight on loans issued to OECD banks is usually lower than for mortgage loans.

w.r.t. $b_{e,t}$

$$\frac{1}{c_{b,t}} = \beta_b E_t(\frac{R_{e,t}}{c_{b,t+1}\pi_{t+1}}) + (1-\tau\chi_2)G_t, \tag{43}$$

w.r.t. d_t

$$\frac{1}{c_{b,t}} = \beta_b E_t(\frac{R_{d,t}}{c_{b,t+1}\pi_{t+1}}) + G_t. \tag{44}$$

2.7.2 Subprime lenders

Subprime lenders operate as financial intermediaries that collect the deposits from the interbank market and issue subprime loans.

Their optimization problem is:

$$\max_{c_{bb,t}} E_0 \sum_{t=0}^{\infty} \beta_b^t (log c_{bb,t}), \tag{45}$$

s.t.

$$c_{bb,t} + b_t''' + R_{b,t-1} bb_{t-1}/\pi_t = bb_t + R_{s,t-1}(1-\delta_{s,t}) b_{t-1}'''/\pi_t \tag{46}$$

Subprime bankers' balance sheet is (we assume that banks hold a reserve for future losses, taking into account ex ante (steady state) default rate):

Assets	Liabilities
Loans to subprime borrowers: b_t'''	Interbank deposits bb_t
Loss reserve $-\delta_s b_t'''$	

Thus a Basel-type capital constraint, given exogenously, has the form:

$$\tau \leq \frac{(1-\delta_s)b_t''' - bb_t}{\chi_2(1-\delta_s)b_t'''}, \tag{47}$$

where the risk weight on subprime loans equals the risk weight on entrepreneurial loans secured by real estate.[6]

The FOCs of the bankers' problem (GG_t denotes Lagrangian multiplier on the capital constraint of subprime lenders) are:

w.r.t. b_t'''

$$\frac{1}{c_{bb,t}} = \beta_b E_t(\frac{R_{s,t}(1-\delta_{s,t+1})}{c_{bb,t+1}\pi_{t+1}}) + (1-\tau\chi_2)(1-\delta_s)GG_t, \tag{48}$$

w.r.t. bb_t

$$\frac{1}{c_{bb,t}} = \beta_b E_t(\frac{R_{b,t}}{c_{bb,t+1}\pi_{t+1}}) + GG_t. \tag{49}$$

[6] Depending on the country, subprime loans may have the same risk weight than prime loans, however, in the US they have been given a higher risk weight if LTV ratio surpasses 0.8 (which is the case for an average subprime borrower).

2.8 Central bank

The central bank implements a Taylor type interest rate rule (similar to Iacoviello (2005), but forward-looking). It is assumed that interest rate set by the central bank equals the interest rate paid on deposits (disregarding reserve requirement):

$$R_{d,t} = (R_{d,t-1})^{r_R} E_t(\pi_{t+1}^{1+r_\pi}(\frac{Y_{t+1}}{Y})^{r_y}\bar{rr})^{1-r_R} e_{R,t}. \tag{50}$$

2.9 Market clearing conditions

The market clearing condition for the housing market is:

$$1 = h_t' + h_t'' + h_t''' + h_{e,t}. \tag{51}$$

As Iacoviello (2005) we assume that real estate is fixed in the aggregate, which guarantees a variable price of housing.[7] The goods market clearing condition is given by:

$$Y_t = c_t' + c_t'' + c_t''' + c_{e,t} + c_{b,t} + c_{bb,t} + I_t. \tag{52}$$

The market clearing conditions for labor are defined by equations 5 and 30 for patient households' labor supply and demand, equations 11 and 31 for impatient prime households' labor market, and by equations 18 and 32 for impatient subprime labor market. The lending to different agents is determined through their collateral constraints and the market clearing conditions for the loan and deposits markets are given by the capital constraints of the bankers (equation 40 and 47).

2.10 Solution method and calibration

The model is log-linearized around the steady state. The log-linearized equations present variables in the form of percent deviations from the steady state, which makes the interpretation of model variables easier. We calibrated the model parameters using values from the literature, as well as empirical papers (for details see Table 1).

Following Iacoviello (2005 and 2011) we assume that patient households have the highest discount factor, followed by entrepreneurs and both types of bankers. The most impatient agents in the economy are prime and subprime borrowers. The choice of discount factors assures that the collateral constraints in the model are always binding. The parameter J controls the stock of residential housing over annual output in the steady state, $J = 0.09$ fixes this ratio around 150%, which is in line with the data from the Flow of Funds accounts (table B.100, row 4). The LTV ratios for different types of borrowers are chosen to match the data in the years preceding the crisis (values for households represent an average for years 2004-2007, based on Paulson and Amromin (2010) and are in line with other studies on the LTV ratios (Demyanyk and Van Hemert (2011)). The data for the LTV ratio on commercial real estate is not as detailed as in households' mortgage case, but $m = 0.75$ is a commonly used value. We assume that residential real estate is easier collateralizable than the commercial real estate. Subprime households' labor share of 0.15 fixes the steady state consumption of subprime borrowers and the share of subprime borrowing in all households' borrowing at around 18%, which means that subprimers account only for around 3% of all borrowing (including entrepreneurs). The

[7] Iacoviello and Neri (2010) relax this assumption. The authors put emphasis on the fluctuations in the US housing market and inspect effects of housing technology shocks. New homes are assumed to be produced with labor, capital, land and intermediate input k_b and there is a productivity shock to housing production technology.

Description	Parameter	Value	Source
discount factor of patient households	β	0.99	Iacoviello (2005)
discount factor of impatient households	$\beta''' = \beta''$	0.96	Iacoviello (2011)
discount factor of entrepreneurs and bankers	$\gamma = \beta_b$	0.98	Iacoviello (2005)
weight on housing services	J	0.09	Flow of Funds table B.100
loan to value prime households	m"	0.761375	data: Paulson, Amromin (2010)
loan to value entrepreneurs	m	0.75	data: Gyourko (2010)
loan to value subprime households	m"'	0.8032	data: Paulson, Amromin (2010)
subprime households wage share	s	0.15	around 18% subprime borrowers
labor supply aversion	$\eta' = \eta'' = \eta'''$	1.01	Iacoviello (2005)
capital share in production function	μ	0.33	data: Jones (2003)
labor share in production function	ν	0.031	Iacoviello (2005)
capital depreciation rate	δ	0.025	10% per year
steady state gross markup	X	1.05	Iacoviello (2005)
patient households wage share	α	0.87	Japelli(1990)
probability fixed price	θ	0.55	Dhyne et al. (2006)
capital adjustment costs	ϕ	2	Iacoviello (2005)
risk weight of interbank loans	χ_3	0.2	US regulation (FDIC)
risk weight of commercial and subprime loans	χ_2	1	US regulation (FDIC)
risk weight of prime mortgage loans	χ_1	0.5	US regulation (FDIC)
capital requirement	τ	0.08	Basel regulation
subprimers' default sensitivity to house price changes	ϕ_{sh}	0.183	data: Paulson, Amromin (2010)
steady state subprime default rate	δ_s	0.05	data (Demyanyk, van Hemmert (2011))
weight of policy response to int.rate	r_R	0.77	Orphanides (2005)
weight of policy response to inflation	r_π	0.89	Orphanides (2005)
weight of policy response to output	r_y	0.18	Orphanides (2005)
autocorrelation of preference shock	ρ_j	0.85	Iacoviello(2005)
autocorrelation of inflationary shock	ρ_u	0.59	Iacoviello(2005)
autocorrelation of technology shock	ρ_a	0.03	Iacoviello(2005)
standard deviation of preference shock	σ_{ε_j}	24.89	Iacoviello(2005)
standard deviation of inflationary shock	σ_{ε_u}	0.17	Iacoviello(2005)
standard deviation of technology shock	σ_{ε_a}	2.24	Iacoviello(2005)
standard deviation of monetary shock	σ_{ε_R}	0.29	Iacoviello(2005)

Table 1: Calibrated parameters

patient households' wage share of 0.87 corresponds to the conclusions of Japelli (1990) who finds out that 19% of US families are rationed in credit markets and they account for 12.7% of total income. The value of 0.55 for the parameter θ describing the price rigidity is consistent with the evidence of Dhyne et. al (2006) who show that the average price duration in the United States equals 6.7 months. The value for the capital adjustment costs follows Iacoviello (2005). Parameters describing the risk weights of different types of loans are based on the US regulation of Federal Deposit Insurance Corporation (Code of Federal Regulations - Title 12: Banks and Banking, 12 CFR Appendix A to Part 325 - Statement of Policy on Risk-Based Capital). The sensitivity of subprime households to house price changes has been chosen according to the pre-crisis data. Over time, the sensitivity changed, however, on average one can assume that it did not exceed 20% (Paulson and Amromin (2010)). Subprime default rate is chosen to be 5% in the steady state. According to the data presented in Demyanyk and van Hemmert (2011), in the decade preceding the crisis, the default rate on subprime hybrid loans was oscillating around

10%. However, usually when a household defaults on its mortgage, the bank seizes and sells the property, receiving some foreclosure value. The present model does not have this feature, thus the steady state default rate is half of that in the data. Also, a higher steady state default rate would result in an unreasonably high steady state value for interest rate on subprime loans. The Taylor rule coefficients are taken from the study of Orphanides (2005). Paramteres describing the autocorrelation and the standard deviation of shocks in the economy have the same values as in Iacoviello (2005).

2.11 Model dynamics

Similarly to Iacoviello (2005) the present model is subject to four different shocks. The monetary shock is defined as an exogenous increase in the interest rate set by central bank and can be interpreted as the move of the central bank which is inconsistent with the usually applied Taylor rule. The inflation shock is defined as an exogenous increase in the inflation rate in the economy and shows up in the Phillips curve. The negative preference shock captures change in preference for housing among households. This may capture - in reduced form - a regulatory or taxation reform which makes the investment in housing less attractive to households (regulatory reforms allowing for a large range of mortgage products could have led to a positive preference shock in the US (see Temkin et al. (2002)). A technology shock is defined as an increase in productivity that is one of the variables in the production function. It may capture some major technological invention that increases the efficiency of the production process.

The present model has two important features distinct from the model of Iacoviello (2005). First of all, it is assumed that prime households have access to long-term loans and that for T periods (here $T = 4$) the interest rate on the given loan contract remains fixed. Moreover, unlike in Monacelli et al. (2011), it is assumed that prime households may borrow up to the future value of their collateral minus their outstanding debt. The difference between the length of the prime and subprime contract should capture the difference between fixed interest rate and variable interest rate loan contracts. One could assume longer maturity of multi-period loans, as well as longer maturity of short-term subprime loans. To check whether the results and conclusions are robust to the changes in the maturity of loans, we also run the model for six-period prime loans and two-period subprime loans (instead of four-period prime loans and one-period subprime loans). The qualitative results of the model do not change in this case, and the quantitative impact is limited. The second distinct feature of the presented model is the existence of subprime borrowers and lenders, and, importantly, the sensitivity of subprime default rate to change prices. The importance of the two model devices is described in the following passages.

Figure 5 shows impulse responses of variables related to the prime borrowers in the economy in the case of one-period loans for all borrowers (solid line) and for the benchmark model (dotted line).[8] We see that in case of all four shocks the introduction of long-term loans for prime borrowers results in a subdued response of primes' housing stock and borrowing as compared to the version of the model in which all borrowers take out loans for one period. We also see that the consumption response of prime borrowers is less responsive to shocks when they borrow for more than one period. The introduction of more period loans amplifies the response of interest rate on prime loans. However, once set, the interest rate for a given loan contract remains fixed for the next T periods. To

[8]The chosen calibration for this exercise slightly differs from the benchmark one. To assure the smoothness of impulse response function and compliance with Blanchard-Kahn conditions for different versions of the model, the commercial bankers' steady state consumption was assumed to be 0.25 and the subprime bankers' consumption to be 0.05. This does not change qualitatively the results.

sum up, the introduction of long-term loans adds realistic features to the model, making the borrowing and consumption of prime borrowers less responsive to different shocks and distinguishing this type of borrowers from subprime and corporate debtors. Lower volatility of final goods consumption as well as housing stock increases the welfare of prime borrowers. In a slightly different multi-period setup Monacelli et al. (2011) (who do not make the collateral constraint depending on the amount of outstanding debt) show (for $T = 2$) that variable interest rates amplify the response of economy after a monetary shock when compared to a fixed rate setup. The present paper confirms this result and extends it to other shocks. Long-term loans for prime borrowers are also an important feature in the version of the model in which subprime loans are securitized (Section 3 of the paper) as they highlight the distinction between private and entrepreneurial borrowers (who borrow only for one-period) and ensure different responses of the both types of borrowers to the reduction in loan supply.

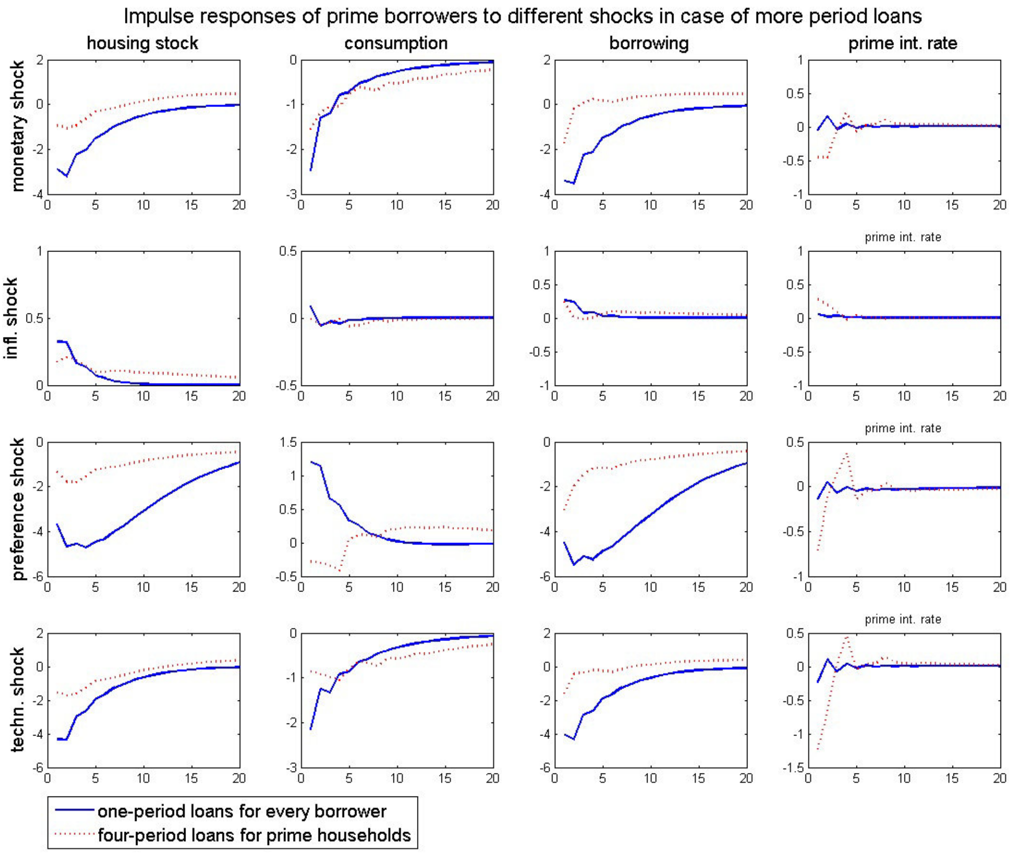

Figure 5: Impulse responses of models without subprimers with one- and four-period loans for primes (in percentage deviations from steady state)

The second important modeling device is the assumption of the existence of subprime borrowers in the economy and the dependence of their default rate on the house prices. Alone the introduction of subprime borrowers and lenders to the model economy does not change the behavior of model variables. However, the assumption of default sensitivity to house prices leads to some amplification effects in the economy, which, though seemingly small, are substantial if we recall that subprimers are assumed to account only for around 3 percent of all steady state borrowing (including lending to firms). To investigate the importance of the assumption about the sensitivity of subprime borrowers to house price changes, the behavior of the benchmark economy is compared with the behavior of an economy in which the default rate is positive in the steady state but does not react to any changes in the economy. Looking at Figure 6 we see that the impulse responses of both economies are almost identical. However, especially in case of a monetary and preference shock, the default sensitivity to house prices leads to an amplification of the house price and the output response to the shocks. The amplification mechanism occurs through the redistribution effect between subprime borrowers and lenders. That redistribution effect resembles the dynamics observed in Iacoviello (2013) after an exogenous financial shock. The varying default rate, precisely, the rising default rate after a negative shock leading to a house price fall, is from the subprimers' perspective a positive wealth effect - they may repay less than contracted. Feeling wealthier, subprime borrowers will reduce their labor supply when compared to the case when the default rate does not vary, which drives the output down. For the subprime lenders, the rising default rate represents a negative wealth effect, because they do not get back all the contracted loan installments. Suffering losses on their loan portfolio, subprime lenders face a tighter capital constraint. They will reduce their lending to subprime borrowers and raise the interest rate on subprime loans, however, also their consumption will go down. Although the described redistribution effect and balance sheet effect have a negative effect on the overall consumption and more responsive house prices affect other borrowers in the economy that use housing stock as collateral for their loans, the subdivision of the banking sector into the subprime and the commercial segments prevents the negative developments in the subprime market to spread to other sectors of the economy, especially the production sector which is unaffected by subprimers' defaults. Thus the observed amplification mechanism is rather small.

The impulse responses to the four shocks in Figure 6 resemble the impulse responses of Iacoviello (2005). After an exogenous increase in the nominal interest rate set by central bank, we observe a fall in inflation and a comovement of house prices and output. The impulse responses are in line with the conventional view of the effects of a monetary shock. An inflation shock, which is estimated to be both not persistent and of small amplitude, leads to a very small fall in house prices and output. The nominal interest rate rises. The negative preference shock for housing stock results in a fall of house prices and output. Also inflation and nominal interest rate show downward dynamics. The model, similarly to Iacoviello (2005), exhibits a comovement of house prices and output responses to different shocks, with the exception of the positive technology shock, after which the house prices go up and output falls. This seemingly contra-intuitive result is driven mainly by two forces in the model - the nominal rigidity and debt deflation effects. In the existence of a nominal rigidity in the model a positive technology shock may lead to a negative short-run effect on the employment (see Galí (1999)). Moreover, a positive technology shock leads to a fall in inflation. Deflation redistributes wealth from borrowers to lenders in the economy and since in the presented setup borrowers are more prone to consume due to their impatience, deflation has a negative impact on the output.

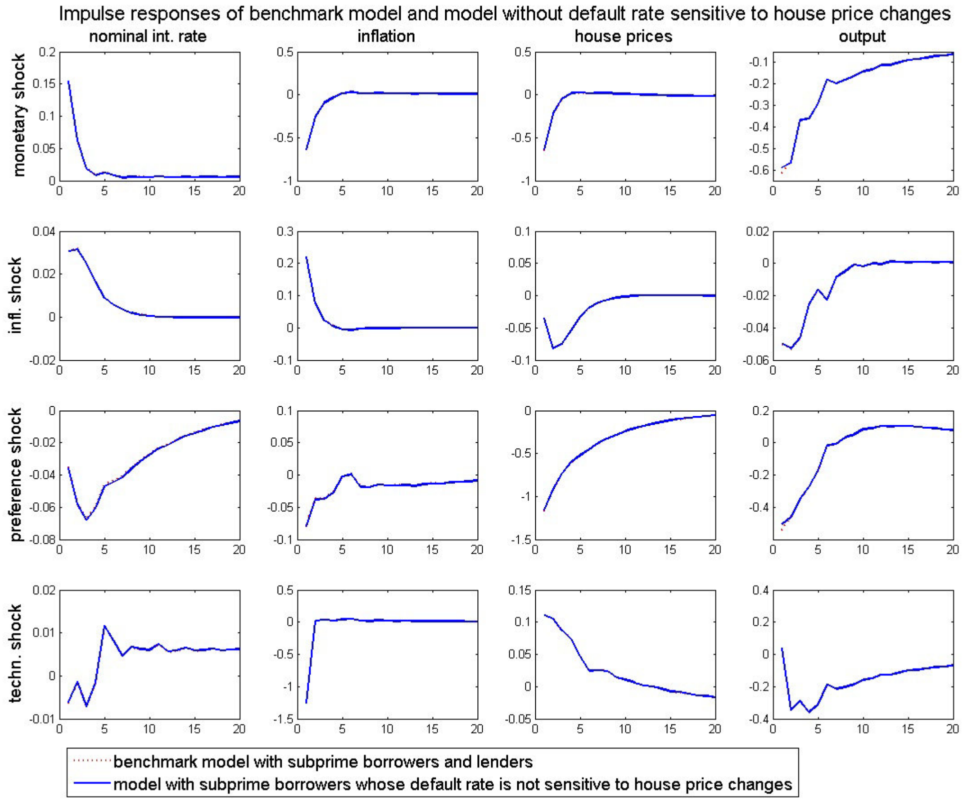

Figure 6: Impulse responses of benchmark model and model without default rate sensitive to house prices (in percentage deviations from steady state)

3 Model with securitization of subprime loans

The data provides evidence for the importance of securitization in subprime lending. The majority of subprime loans have been securitized, first in form of a RMBS that often was a building block of CDO structures. Usually, different subprime borrowers have different default probabilities, so securitization may be a way to average the risk on subprime exposure. In the present model, all subprime borrowers have the same default rate. However, we can think about that default rate as the default rate representing the aggregate distribution over all subprime borrowers, who differ in their default sensitivity at an individual level. Typically, an MBS structure consists of three tranches: senior, mezzanine and equity. To simplify the computation, we assume that the model's RMBS consists only of two tranches: senior and equity.[9] Figure 7 illustrates the payoff functions of investors in the RMBS. The security is a pass-through security, which means that the nominal loan proceedings are redistributed to the MBS investors. The payoff of equity tranche investors is the larger, the smaller the loss on the underlying loan portfolio (determined by the default rate). The size of the equity tranche defines the maximal risk

[9]Gorton (2008) argues that subprime securitization differs from the securitization of other assets because the tranche sizes are not fixed. There is dynamic tranching as a function of excess spread and prepayments, so the whole structure is sensitive to house prices. At the beginning of the existence of a subprime MBS, the equity tranches are usually very thin and along with repayments of the subprime loans they reach their target level. However, if house prices decline from the very beginning, the equity tranche remains very thin and thus senior tranche holders are subject to a very large subprime risk (that was the case for MBS issued in 2006 and later). This works as another amplification mechanism in the design of subprime security. In the presented model it is assumed that tranche sizes are fixed from the beginning. Including varying tranche sizes in the model would amplify the effects of shocks in the economy.

exposure of equity tranche investors. If there is a loss on the underlying loan portfolio, the equity tranche investors get the difference between the size of the equity tranche and the loss. However, if the loss exceeds the size of the tranche, the equity tranche investors simply get nothing from their investment, and the senior tranche investors begin to suffer. Their payoff function is a minimum function. They either get back the tranche size, or the difference between the face value of the MBS and the loss (in case when losses are bigger than the size of the equity tranche). $P_{s,t} = min(S_t - fS_t, S_t - Loss_t)$ denotes the payoff of senior tranche buyers and $P_{e,t} = max(fS_t - Loss_t, 0)$ denotes the payoff of equity tranche buyers, where the principal of the MBS is (in real terms) $S_t = R_{s,t-1}b'''_{t-1}/\pi_t$, loss equals $\delta_{s,t}S_t$. Cash flows obtained from subprime loans (in real terms) are equal to $S_t(1 - \delta_{s,t}) = R_{s,t-1}b'''_{t-1}(1 - \delta_{s,t})/\pi_t$.

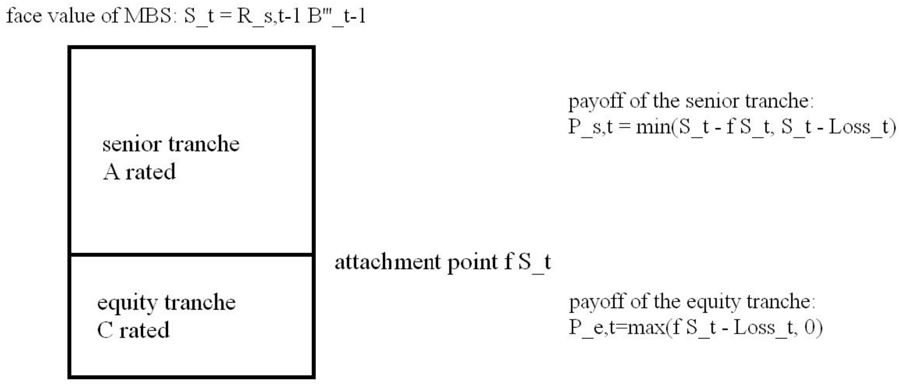

Figure 7: A two tranche MBS

How is the face value of the security divided into the two tranches? The equity tranche will absorb the losses up to a certain point, called in the CDO jargon the attachment point (defined in the model by a parameter f). The parameter f describes the amount of subordination the senior tranche enjoys. If losses on the portfolio are bigger than the thickness of the equity tranche (determined by the parameter f), the senior tranche holders start to suffer. The equity tranche suffers losses from 0% to f (attaches at 0% and detaches at f), whereas the senior tranche suffers all losses that are bigger than percentage f of the face value of the security (the tranche attaches at f and detaches at 100%). Independently on the outcome, the cash flows distributed to investors always equal cash flows from subprime loans (including losses), which is illustrated in Table 2:

	Scenario	
	Loss is bigger than the equity tranche $\delta_{s,t}S_t > fS_t$	Loss is smaller than the equity tranche $\delta_{s,t}S_t < fS_t$
payoff of equity tranche holder	0	$fS - \delta_{s,t}S_t$
payoff of senior tranche holder	$S_t - \delta_{s,t}S_t$	$S_t - fS_t$
sum of payoffs	$S_t - \delta_{s,t}S_t$	$S_t - \delta_{s,t}S_t$

Table 2: MBS payoffs - two scenarios

Note that while evaluating the expected payoff of tranches, $E_t(Loss_t) = E_t(\delta_{s,t+1}S_{t+1})$ is unknown, because the default rate is a jump variable. The payoffs of equity and senior tranche holders resemble payoffs from investment in European options. A European option is a financial instrument that gives the holder the right (but not obligation) to buy (in case of a call option) or to sell (in case of a put option) the underlying asset at a certain price (reference price, called also strike) at a certain period in time (expiration date of the option). Buying a call option or writing (selling) a put option, we bet on the increase of the underlying asset price. Selling a call option (having a short call position) or buying a put option (having a long put position), we bet on the fall in the underlying asset price. The holder of an equity tranche of the MBS gets payoffs equal to the ones from a long put position - he invests in the hope that the default rate (underlying asset) will decrease. Also investing in a senior tranche of an MBS is profitable when the default rate decreases. Note that

$$P_s, t = min(S_t - fS_t, S_t - \delta_{s,t}S_t) = S_t(1-f) - max(S_t\delta_{s,t} - fS_t, 0) = S_t(1-\delta_{s,t}) - max(fS_t - \delta_{s,t}S_t, 0). \tag{53}$$

Thus the payoff of the senior tranche can be rewritten as having a long position in the face value of the tranche and a short call position, or a long position in the cash flows from subprime loans and a short put. Notice that both in the case of the equity tranche and the senior tranche payoff we can factor out the face value of the MBS, S_t. The underlying asset for the investors of MBS tranches is the default on subprime loans $\delta_{s,t}$, whereas the exercise price of the options they trade equals f (our attachement point of senior tranche). Figure 8 visualizes the profit (on the vertical axis) of investing in a short call and long put position depending on the default on subprime loans (horizontal axis). The lower the default, the higher the profit of investors (or the lower the loss).

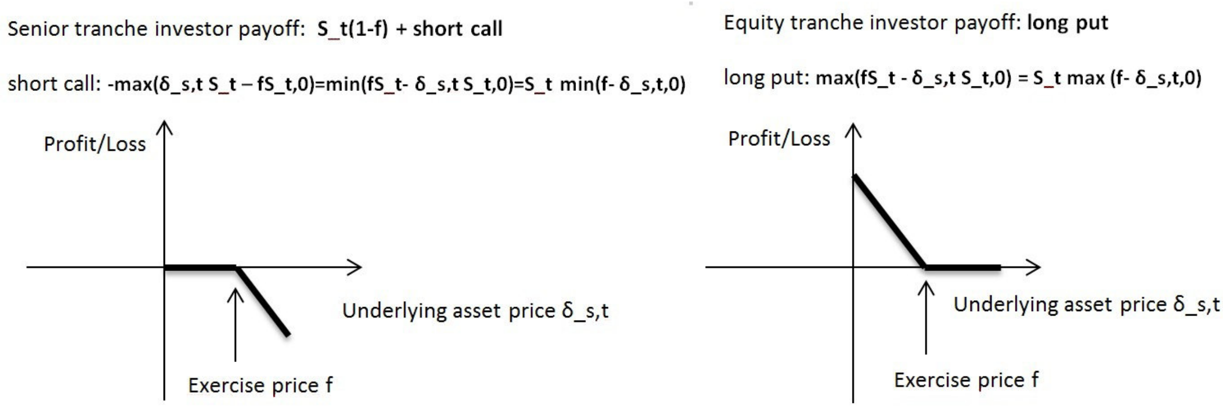

Figure 8: Option position of MBS investors

After a shock, payoffs are realized and it is known whether the loss was bigger than the size of equity tranche. Thus the investors get a well-known proportion of subprime cashflow. However, while deciding about the investment in the next period, they take into account the expected future value of payoffs to evaluate the amount of money they want to pay for the given tranche. Thus an appropriate expression for $E_t[min(S_{t+1} - fS_{t+1}, S_t - \delta_{s,t+1}S_{t+1})]$ and $E_t[max(fS_{t+1} - \delta_{s,t+1}S_{t+1}, 0)]$ is needed. As noted before, in both cases the $E_t[S_{t+1}]$ can be factored out. However the uncertainty remains with respect to the development of $E_t[\delta_{s,t+1}]$. One can use the Black-Scholes formula to evaluate payoffs, but this requires certain assumptions that cannot be made here (stable volatility of default rate, risk-free interest rate). However, there is a simple method allowing to smoothly approximate a function with a kink, like the ones drawn above. The logistic function provides a very good approximation of maximum and minimum functions, which makes the solution tractable.[10] The maximum and minimum payoffs can be thus approximated with a logistic function: $E_t[max(f - \delta_{s,t+1}, 0)] \approx E_t[f - \frac{\delta_{s,t+1}-f}{1+e^{(\delta_{s,t+1}-f)}}]$,

[10] Actually, logistic function is used in one of the financial methods of estimating the value of securitized products. In finance, apart from Black-Scholes formula and copula methods for option pricing, neural networks have been used to price options (that have a logistic function in the solution) at least since the publication of Hutchinson et al. (1994).

whereas $E_t[max(\delta_{s,t+1} - f, 0)] \approx E_t[-f - \frac{\delta_{s,t+1}+f}{1+e^{(-\delta_{s,t+1}+f)}}]$. Equation (53) shows three analogous representations of payoff that goes to senior tranche holders. From this representation one can see that the minimum function can be rewritten in such a way that only one approximation with the logistic function has to be made to find expected payoffs of both tranche holders (for long put). Having rewritten expected payoffs using the approximating function, one can log-linearize the conditions determining the behavior of price of MBS tranches and consumption of agents engaged in the transaction.

To investigate whether the engagement of commercial banks in the securitization process could be one of the factors amplifying the negative results of different shocks in the economy, we consider two cases. In the first case, we assume that the generated MBS tranches are bought by patient households (because they are more patient, they acquire claims on the senior tranche) and entrepreneurs (because of their degree of impatience, they are more prone to acquire claims on the equity tranche). In the second case, we assume that the commercial bankers buy senior tranche of the MBS and the entrepreneurs invest in the equity tranche (one could also assume that the commercial bankers buy both the equity and the senior tranche, which would be a more extreme case and would lead to qualitatively stronger results). In both cases subprime lenders retain a vertical fraction t of the issued security (equivalent to retaining percentage t of cash flows).[11] Why may commercial bankers buy claims on MBS? For example to diversify their credit risk and get exposure to a different credit market. Also, they may be as optimistic as subprime borrowers are, and believe that the house prices will continue to rise. Moreover, senior tranches usually have the highest possible rating, so the risk weight on them is very low and the purchase has a positive impact on the balance sheet of the banks. Why may patient households and entrepreneurs buy MBS tranches? For them this investment is just another possibility to smooth their consumption.

We assume that certain agents in the economy invest in the MBS securities and we do not model their decision as a portfolio choice decision. The reason for it is that under the first order approximation the portfolio decisions are not well-defined. Moreover, the investment decisions of the MBS investors were not made optimally anyway due to a range of reasons, among them the lack of information. Also, many institutional investors invested in the MBS because the securitized products offered a higher return than safe assets but were seemingly of the same risk as the diversification and repackaging were believed to reduce the risk and secured a high rating even for the subprime MBS. Short-term oriented compensation schemes in the financial industry were also a part of the problem. Since this paper focuses more on the possible transmission channels of the recent crisis than its microfoundations, we take the shortcut and assume two cases of securitization to compare their different effects on the economy.

3.1 Version in which patient households and entrepreneurs invest in MBS tranches

In the first version of the model with securitization of subprime loans patient household invest in the senior tranche, and entrepreneurs in the equity tranche.

The budget constraints of investors change and a new term describing the investment in derivative security appears. First denote the payoff of senior tranche $min(S_t - fS_t, S_t - \delta_{s,t}S_t)$ as $MBS_{s,t-1}$ and $E_t[min(S_{t+1} - fS_{t+1}, S_{t+1} - \delta_{s,t+1}S_{t+1})]$ as $MBS_{s,t}$ and the price

[11] In general, literature discusses three main types of retention: vertical slice retention, horizontal slice retention, and an equivalent exposure of the securitized pool, discussed further in Geithner (2011). In the presented model's case, vertical slice retention generates the same payoff for the bank as equivalent exposure.

of the senior tranche by $p_{s,t}$. Then the budget constraint of the patient household is (remember that subprime lenders retain portion t of every tranche):

$$c'_t+q_t(h'_t-h'_{t-1})+d_t+(1-t)p_{s,t}MBS_{s,t} = R_{d,t-1}d_{t-1}/\pi_t+w'_tL'_t+F_t+(1-t)MBS_{s,t-1}. \quad (54)$$

Each period patient household gets revenue from investing in the senior tranche and buys a claim on future proceedings from investment in the MBS. The FOCs of prime households do not change but there is a new equation determining the price of the new claim.

$$\beta\frac{1}{c'_{t+1}} = p_{s,t}\frac{1}{c'_t}. \quad (55)$$

Analogously, denote the terms describing the investment in the equity tranche $E_t[max(fS_{t+1}-\delta_{s,t+1}S_{t+1},0)]$ as $MBS_{e,t}$ and $max(fS_t-\delta_{s,t}S_t,0)]$ as $MBS_{e,t-1}$ and the price of the equity tranche by $p_{e,t}$. Then the budget constraint of the entrepreneur is:

$$\frac{Y_t}{X_t}+b_{e,t}+(1-t)MBS_{e,t-1} =$$
$$c_{e,t}+q_t(h_{e,t}-h_{e,t-1})+\frac{R_{e,t-1}}{\pi_t}b_{e,t-1}+w'_tL'_t+w''_tL''_t+w'''_tL'''_t+I_t+\xi_{K,t}+(1-t)p_{e,t}MBS_{e,t}. \quad (56)$$

The FOC w.r.t to the new claim is:

$$\gamma\frac{1}{c_{e,t+1}} = p_{e,t}\frac{1}{c_{e,t}}. \quad (57)$$

Apart from the optimization problems of agents investing in the security, also the problem of subprime lenders changes in the wake of securitization of subprime loans. They have only to include the retained proportion of subprime loans in their balance sheet:

Assets	Liabilities
Loans to subprime borrowers: tb'''_t	Interbank deposits bb_t
Loss reserve $-t\delta_sb'''_t$	

Thus a Basel-type capital constraint, given exogenously is:

$$\tau \le \frac{t(1-\delta_s)b'''_t-bb_t}{\chi_2t(1-\delta_s)b'''_t}. \quad (58)$$

The budget constraint of subprime lenders changes. Note that when it comes to the transfer of already realized cashflows, we have:
$(1-t)[min(S_t-fS_t,S_t-\delta_{s,t}S_t)+max(fS_t-\delta_{s,t}S_t,0)] = (1-t)[S_t(1-\delta_{s,t})] = (1-t)[R_{s,t-1}b'''_{t-1}(1-\delta_{s,t})/\pi_t]$, whereas in case of the purchase of claims on future proceedings this shortcut cannot be made because the prices of both tranches differ, since the agents that buy them have different discount factors. Thus the budget constraint of subprime lender is:

$$c_{bb,t}+b'''_t+R_{b,t-1}bb_{t-1}/\pi_t-(1-t)[p_{s,t}MBS_{s,t}+p_{e,t}MBS_{e,t}] =$$
$$bb_t+tR_{s,t-1}(1-\delta_{s,t})b'''_{t-1}/\pi_t. \quad (59)$$

The prices of tranches are determined by equations (55) and (57).

3.2 Version in which commercial bankers and entrepreneurs invest in MBS tranches

In the second version of the model with securitization commercial bankers invest in the senior tranche, whereas entrepreneurs, as in the first case, buy claims on the equity tranche. The problem of entrepreneurs does not change with respect to the version of model when patient households and entrepreneurs buy MBS tranches. The budget constraint of commercial bankers changes then, as well as their balance sheet and capital constraint. We assume here that the risk weight on senior tranche is as high as in case of interbank deposits (since it is highly rated), whereas the risk weight on equity tranche equals the risk weight of subprime loans.

Commercial bankers' balance sheet is:

Assets	Liabilities
Loans to prime borrowers: b''_t	Deposits d_t
Interbank loans : bb_t	Equity eq_t
Loans to entrepreneurs: $b_{e,t}$	
MBS security - senior tranche: $(1-t)MBS_{s,t}$	

Thus a Basel-type capital constraint, given exogenously, has the form:

$$\tau \leq \frac{b''_t + bb_t + b_{e,t} + (1-t)MBS_{s,t} - d_t}{\chi_3 bb_t + \chi_1 b''_t + \chi_2 b_{e,t} + \chi_3 (1-t)MBS_{s,t}}. \tag{60}$$

The budget constraint of commercial bankers is now:

$$c_{b,t} + R_{d,t-1}d_{t-1}/\pi_t + b''_t + bb_t + b_{e,t} + (1-t)p_{s,t}MBS_{s,t} =$$
$$d_t + R_{b,t-1}bb_{t-1}/\pi_t + 1/T\sum_{j=1}^{T}\frac{R_{T,t-j}b''_{T,t-j}}{\prod_{i=0}^{j-1}\pi_{t-i}} + R_{e,t-1}b_{e,t-1}/\pi_t + (1-t)MBS_{s,t-1}. \tag{61}$$

New FOC:

w.r.t. $MBS_{s,t-1}$

$$\beta_b \frac{1}{c_{b,t+1}} = p_{s,t}\frac{1}{c_{b,t}}. \tag{62}$$

The problem of subprime lender is the same as in the case when patient households and entrepreneurs buy MBS tranches.

3.3 Calibration

Parameters chosen for calculation are presented in Table 3[12]:

[12]Evidence suggests that on average retention of securitized assets is higher in Europe than in the US. Whereas in Europe originators usually held around 5% of issued securities, in the US the retention rate was often at 0% and rarely exceeded 1% for MBS. Retention percentages for CDOs and ABS were usually higher, but in years 2002-2009 on average did not exceed 7% (Global Financial Stability Report, October 2009, p. 100-107).

Description	Parameter	Value	Source
tranche retention by banks	t	0.01	Global Financial Stability Report (2009)
attachment point of senior tranche	f	0.2	Hull, White (2010, p.3)

Table 3: Calibrated parameters in the model with securitization

3.4 Results

Figure 9 presents the impulse responses of the benchmark model (solid line) and two versions of model with securitization. The dashed line shows the responses of the model in which patient households and entrepreneurs buy MBS tranches, whereas the dotted line shows the responses of model in which commercial bankers and entrepreneurs buy MBS tranches. In case of all four shocks we see that the model in which patient households acquire claims on senior tranche and entrepreneurs on equity tranche, the output response is smaller than in the benchmark case. Due to the securitization, the capital constraint of subprime lenders becomes looser and their consumption is less responsive to shocks than in the benchmark model. Of course, buying claims on MBS tranches changes the budget constraints of the investors and has impact on their consumption, however they can absorb losses on MBS through working and saving (patient households) or borrowing (entrepreneurs). The overall effect of securitization is positive, because the risk is spread among different agents in the economy. This is the way how the securitization was expected and supposed to work.

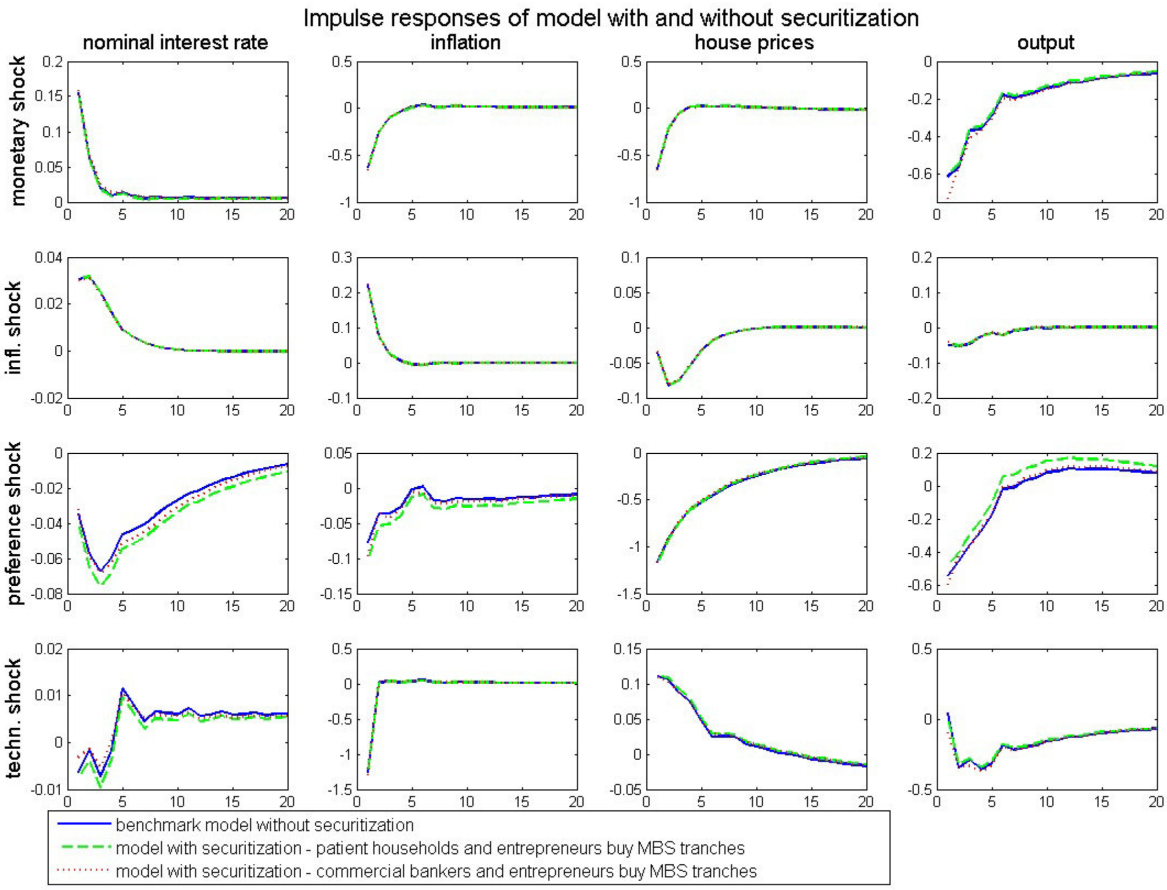

Figure 9: Impulse responses of models with and without subprime securitization

However, also another possibility was considered - that commercial bankers (instead of patients) buy senior MBS tranches. Looking at Figure 9 we see that if securitized assets are bought by commercial bankers and entrepreneurs, there is an amplification of output response after two shocks - the monetary and preference. The amplification occurs not only in comparison to the version of model in which securitized products are bought by patients and entrepreneurs, but also with respect to the benchmark model without securitization. What is the reason for this amplified contraction? The contraction is not driven by the losses of commercial banks due to the investment in the senior tranche of MBS, because in case of all shocks the equity tranche investors (entrepreneurs) cover the majority of losses on the subprime portfolio. The net payoff from the investment in the senior tranche of the MBS is almost negligible for the commercial bankers (and it is slightly negative only in case of the monetary shock), since they price the MBS tranche taking into account possible subprime defaults. All the effects occur through balance sheet of both types of bankers. Issuing MBS makes the capital constraint of subprime lenders looser (in case of a negative shock), whereas it tightens the capital constraint of commercial bankers because they hold the senior tranche of the MBS (that is declining in value after a negative shock increasing the default rate) on their balance sheets. To reduce the tightness of the constraint, commercial bankers may either reduce their consumption or lending (similar mechanism occurs in Iacoviello (2013)). In the present model, they do both. There are two debtors that borrow from commercial banks - prime impatient households that borrow long-term to finance their final goods' consumption and housing stock, and entrepreneurs that use short-term loans to finance their production. The reduction of lending hits entrepreneurs most, who borrow for one-period. As shown before, the assumption that prime borrowers have access to long-term loans makes their responses to shocks smoother. Thus when a negative shock hits the economy and commercial bankers buy senior MBS tranches, their capital constraint gets tighter and they reduce mostly the lending to entrepreneurs who finance housing stock purchases with the money from bank. As housing stock is a production factor, the output in economy goes down more than without the securitization. When non-banks buy MBS tranches, there is a direct effect of this investment on the consumption of the investors, but there is no loss on the balance sheet of the commercial bankers and thus the intermediation process is unaffected and the securitization has an overall positive effect. In the benchmark case the entrepreneurs are unaffected by the defaults in the subprime sector, through the securitization, when the commercial bankers engage in the transaction, a link is created between the production sector and the subprime mortgage market, so that indirectly the entrepreneurs suffer from losses in the subprime portfolio. This dynamics is visible in the Figure 10 that presents chosen model variables after a monetary shock.

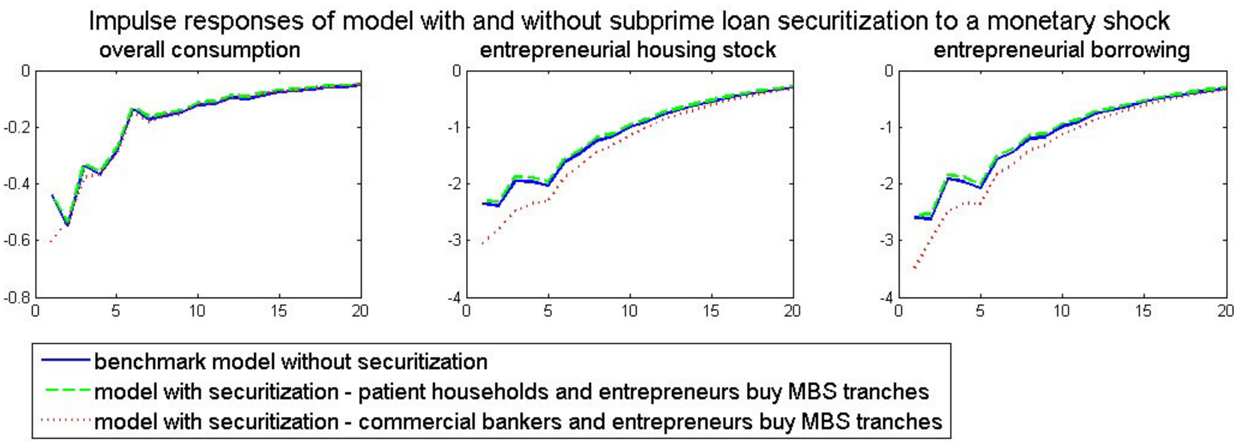

Figure 10: Impulse responses of models with and without subprime securitization after a monetary shock

The fact that bankers face a capital constraint is crucial for obtaining the above result. Because the binding capital constraint leads to a disruption of the credit process when bankers engage in the securitization process, it is better for the model economy when the regulatory constraint is set at a lower level. Thus, the higher the initial leverage of the banks, the less pronounced negative results of the securitization in our model. This seemingly paradoxical result stems from the fact that it is indeed the constraint that the bankers face that turns out to be the main friction in this case.

Model results suggest that the presence of the securitized products on the balance sheet of the banks might be negatively correlated with the value of commercial loans given out to entrepreneurs or, specifically, with the value of commercial real estate loans. This conjuncture is easy to check in the data for the assets and liabilities of commercial banks in the United States. Figure 11 shows total MBS (both agency and non-agency MBS) as the percentage of total bank assets (solid line), commercial real estate loans as the percentage of total bank assets (dotted line), as well as commercial loans (broader category, includes also industrial loans, not necessarily collateralized by real estate) as the percentage of total bank assets (dashed line). We see that indeed the percentage of MBS on the balance sheets of banks is negatively correlated with both other series. Whereas for the considered time period the correlation coefficient between total MBS and commercial real estate loans as percentage of total assets is -0.39, the correlation between total MBS and commercial loans as percentage of total assets is already -0.76. Thus, the data seems to support model's result that securitized assets might have partially crowded out lending to entrepreneurs in the US.

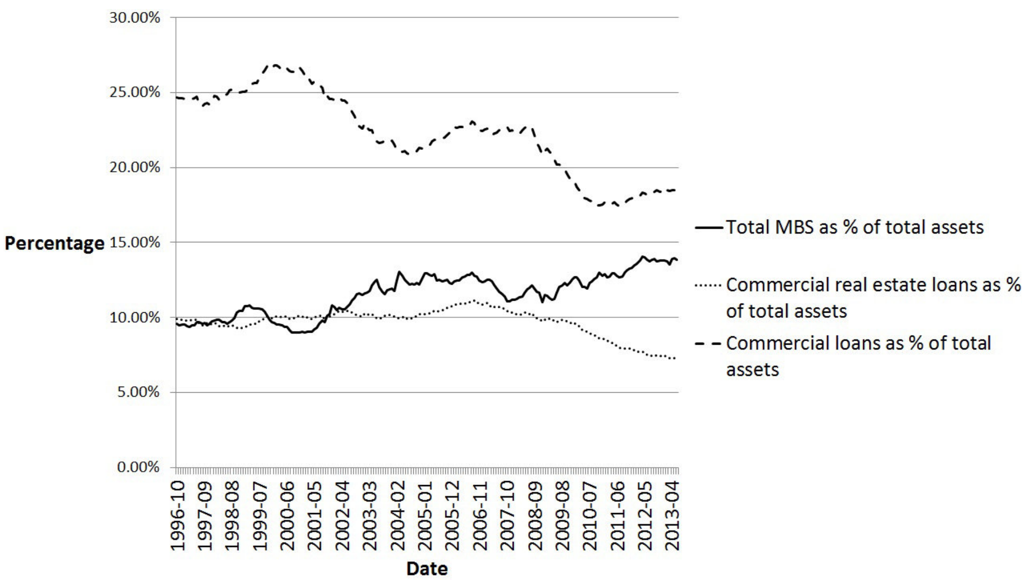

Figure 11: Different asset categories as percentage of total assets 10.1996-06.2013 (monthly data)

Source: Federal Reserve, Table H.8 Assets and Liabilities of Commercial Banks in the United States, Series: B1301NLGAM, B1303NLGAM, B1151NLGAM, B1023NLGAM, B1219NLGAM.

3.5 Crisis experiment

The first graph in the paper showed the evolution of GDP growth and house prices in the US in period 1975-2010. The last NBER recession was defined when house prices already surpassed their peak and began to fall. The difference in house prices between the end period of the recession and the starting period was around - 9.3 percent. During this time, as can be seen on the graph, the GDP growth experienced a plunge of - 9.4 percent.

To see how different models perform in such a situation, we carried out a crisis experiment, calibrating the standard deviation of the preference shock in such a way that the house price fall in the model corresponds to the fall we observed during the last recession. The results are shown in Figure 12. The benchmark model is represented by the solid line, dashed model represents the model with securitization in which patients and entrepreneurs invest in the MBS, and the dotted line shows the responses of the model with securitization, in which commercial bankers and entrepreneurs buy MBS tranches. We see that after a negative preference shock, the fall in output, overall consumption and lending are most severe in the case when subprime loans are securitized and MBS sold to commercial bankers. The difference to the benchmark model is most visible in the first quarters after the shock. When patients and entrepreneurs buy MBS tranches, the response to the shock is visibly smaller. The benchmark model's responses lie in-between the other two models' responses. The housing price dynamics is the same in all three cases. The output fall in the case of subprime securitization and commercial bankers as MBS investors amounts to ca. 5 percent, so the model is not able to fully explain the crisis dynamics, but it may present one amplification mechanism that played the role in the crisis.

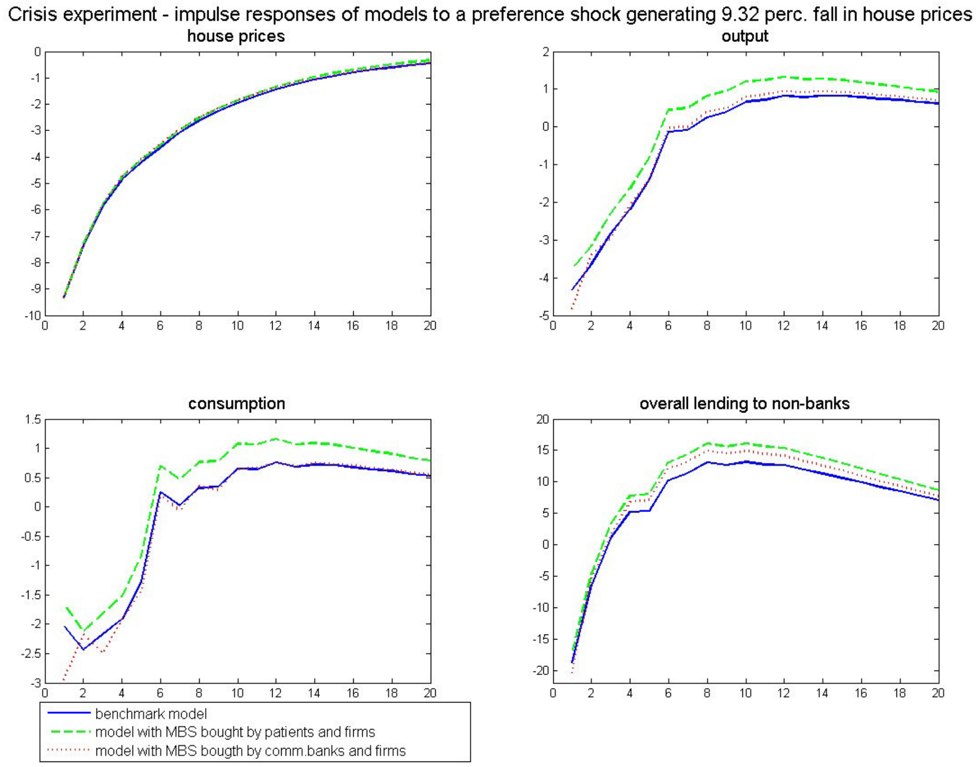

Figure 12: Crisis experiment - impulse responses of models to a preference shock generating 9.32 percent fall in house prices

4 Conclusion

In this paper, we analyzed the importance of the specific design of subprime contract and securitization of subprime loans in generating cyclical fluctuations in the US in a New-Keynesian model based on Iacoviello (2005). The model incorporates four shocks: monetary, inflationary, preference and technology. The evidence suggests that even if subprime borrowers account for a very small percentage of overall borrowing, their existence and the sensitivity of their default rates to house prices amplify the response of output and house prices to different shocks in the economy - however, under the chosen calibration this effect is small. The paper also gives an answer to the question whether the securitization of subprime loans could be a factor amplifying the response of the economy to negative shocks, as the one we observed during the Great Recession. It turns out that the effects of securitization of subprime loans depend on who is the buyer of securitized assets. If households and entrepreneurs purchase the MBS tranches, securitization has a positive effect on the economy, spreading the subprime risk among different agents. Facing a negative shock and losses on securitized portfolio, these agents adjust their labor supply and saving decisions (patient households) or borrowing (entrepreneur) so as to cushion the effects of the exogenous disturbances. However, if financial intermediaries (that are source of credit to households and firms in the economy) purchase the MBS tranches, the securitization has negative effects. It results in a bigger contraction of output after a negative shock when compared with the case in which non-banks buy the MBS tranches or without securitization. The risk-sharing aspect is absent in this situation, because the capital constraint on the side of the banks is a source of additional financial frictions. The assumptions that the default rate moves endogenously with changes in house prices and that part of the borrowers have access to long-term loans are crucial for obtaining the final result.

The results of the paper are in line with narrative explanations of the crisis provided by Hellwig (2008) and Jaffee et al. (2009). It is shown that securitization per se cannot be blamed for the crisis, because it may have a positive impact on the economy, as hoped for, if the securitized products are bought by agents that do not play the role of a financial intermediary in the economy. Obviously, it may be that unless there was the possibility of securitization, the bankers would not issue as many subprime loans as they did in the first place. The present paper deals however with the possible transmission mechanism in an economy with subprime borrowers and securitization and not the reasons for the existence of the subprime market and the subprime securitization with their incentive problems.

To sum up, the paper combines the macroeconomic framework with financial economics, presenting one important channel that might have played a role in the amplification of the recent crisis in the US economy. It provides evidence that financial intermediaries and the constraints they are facing are an important feature of macroeconomic models.

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