LAND REFORM IN THE CREDIT CYCLE FRAMEWORK: THE CASE OF UKRAINE

by

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Abstract

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In the present work I state that the land reform may affect the business cycle dynamics through the financial accelerator. For this purpose, I embedded agricultural land in a conventional framework for Dynamic Stochastic General Equilibrium models with collateral constraints. The model was estimated based on the Ukrainian data and examined with the impulse response function analysis. I found that collateralization of agricultural land leads to a quantitatively significant additional loan-to-value shock amplification compared to the case when the land cannot be used to secure loans.

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GLOSSARY

Word

NBU – National Bank of Ukraine

STATEGEOCADASTRE – The State Service of Ukraine for Geodesy, Cartography and Cadastre

SVDEVELOPMENT – SV Development

UKRSTAT – State Statistics Service of Ukraine

C h a p t e r   1

INTRODUCTION

The recession of 2008 remains the most noticeable event in the decade that past and the most remarkable financial crisis since Great Depression (Temin, 2010). Not surprisingly, the economic slowdown turned out to be a milestone in the development of macroeconomic theory, engendering a substantial attention to financial accelerator, which was reflected in the Dynamic Stochastic General Equilibrium (DSGE) modeling. Though the foundation for this kind of DSGE models was laid long before the crisis, prolific works on the matter often refer to the recent years.

This work draws motivation from the overpast crisis considering the financial sector as one of the key drivers of output fluctuations during the cycle. To substantiate this statement in the case of emerging economy I partially replicated VAR evidence of Iacoviello (2005, Figure 1 "VAR Evidence, United States", p.741) based on the Ukrainian data. I used 2006Q1-2016Q4 time series on private consumption spending (seasonally adjusted, $; data source: UKRSTAT, own calculations), interest rate (interest rates on interbank deposits 1-3 months; data source: NBU), consumer price index (data source: UKRSTAT) and real estate price ($ per m2, Kyiv, residential real estate, secondary market; data source: SVDEVELOPMENT).

Figure 1 represents comovement of consumption and house prices observable from the Ukrainian data. This relation can be explained by the collateral effect. The mechanism is rather straightforward: in economy with borrowing constraints a positive shock leads to the constraint relaxation, allowing higher consumption spending. Houses usually serve as a mean of collateral that reveals a positive correlation between its prices and consumption.

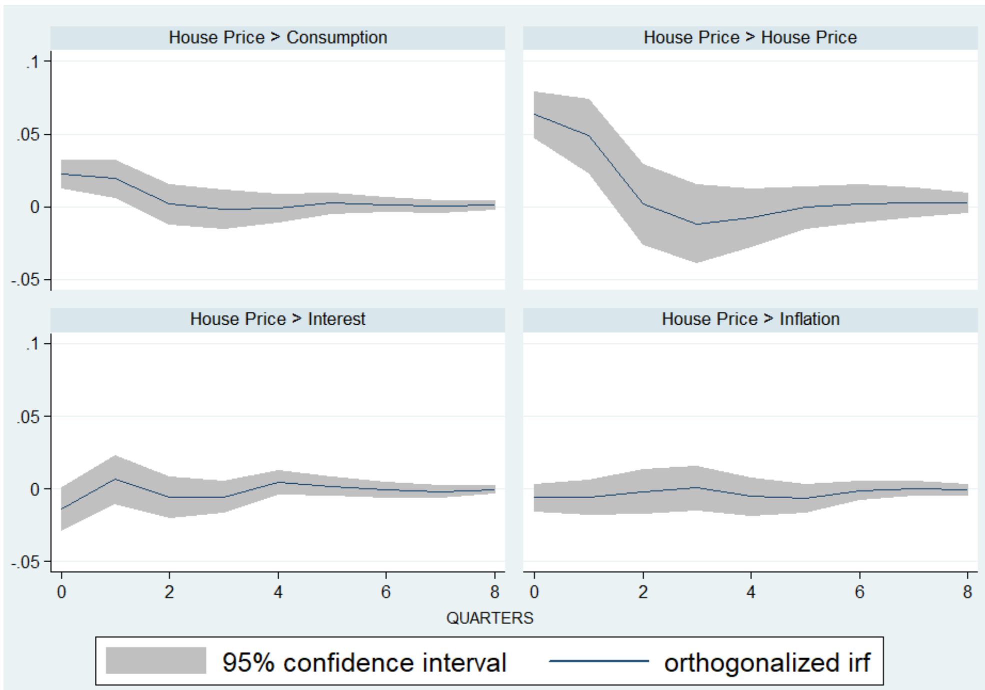

Figure 1. IRF to the house price shock

The collateral effect plays an important role in generating fluctuations and approaches to the quantitative borrowing restrictions modeling differs in many respects, yet retaining the gist. Consumers and entrepreneurs can borrow against some proportion of the value of their assets, usually houses (for instance, Gerali(2010), Iacoviello(2015)) or land (Kiyotaki and Moore (1997), Liu, Wang, and Zha (2013)). Considering houses as a medium to secure a loan, I made an attempt to reveal some macroeconomic consequences of instantaneous allowing agricultural land to serve as a mean of collateral as well. This work can be treated as one that studies exogenous increase of the collateral amount in the context of the credit cycle framework. Moreover, this statement of purpose will allow to trace mutual price dynamics of two collaterals introduced in a different way.

To simulate the changes caused by possible transformation, I extended the DSGE model with collateral constraints by introducing farmland as potentially an additional way to secure a loan. I developed two models: "initial" and "modified", which represent the economy before and after the land reform and examined their properties with impulse response function (IRF) analysis.

The models are constructed identically in all aspects except land. The model setup to a large extent follows and inherits the majority of features of the framework elaborated by Iacoviello(2005) and further developed by Iacoviello and Neri(2010), Gerali(2010), Iacoviello(2015). It is the Dynamic Stochastic General Equilibrium Model with monopolistic competition on the retail level and collateral constraints originated from Kiyotaki and Moore(1997). Borrowings should be secured by the value of houses which, are in possession of borrowers in the "initial" model and by the value of houses or land in the "modified" one that constitutes one of the key differences between the models. Using land as a collateral may ease the borrowing constraint thereby altering business cycle dynamics via financial accelerator.

In other respect, the frameworks differ in a possibility of the land merchandise. The model that simulates the economy after the agrarian reform enables land to be sold, while the initial model does not. In this fashion current paper tries to imitate changes in the transmission mechanism in the economy of Ukraine that will take place in the nearest future. Both "initial" and "modified" models are estimated based on the Ukrainian data and are the subject of two standards (technological and monetary), one preference (housing demand) and one financial (loan-to-value ratio) shocks. Both models are closely examined and compared by means of the IRF analysis.

The remainder of this work is organized as follows. Chapter 2 presents a brief overview of legal status of agricultural land in Ukraine. Chapter 3 proceeds with literature review. I incorporated agricultural land in general equilibrium setup in chapter 4. The thesis concludes by parametrization in chapter 5, results in chapter 6 and conclusions in chapter 7.

Chapter 2

AGRICULTURAL LAND IN UKRAINE

The fall of the Soviet Union accompanied by the gaining of independence brought Ukraine on the way of liberal transformations. An example of such transformations is the land reform, which was launched in March 1991. The Law on Forms of Land Ownership (1992) abolished more than seventy-five-year state monopoly on the right to own land and the Land Code (1992) validated the way of transferring land from the state to private or collective ownership. The transfer of land to collective ownership was a transitional stage on the way to full privatization, allowing to conduct the transformation gradually.

The next stage of the reform was related to the Decree on the Order of Land Division (1995) and delineated the procedure for the transition from collective to private ownership on land. As a result, by the end of the century collective farms were reorganized and about 28 million hectares of agricultural land was transferred into private ownership. This land was distributed as "pays" (shares) at no cost among the workers who participated in collective farms.

At the beginning of the 2000's the population that received agricultural land during the process of privatization had no means of production enough for individual farming, which potentially created a threat of land accumulation in the hands of big enterprises. To avoid the unfavorable consequences of the market formation moratorium on the land (pays) sale was introduced by Verkhovna Rada as a temporary measure (for four years) in 2001. The law prohibits any transfer of ownership of "pays" other than inheritance, including land sale and land donation. The moratorium was prolonged 8 times and currently expires on 1 January 2019. As the moratorium does not leave any legal ways for farmland expropriation, it cannot be use as a mean of collateral. At the moment, loan-to-value ratio for agricultural land is zero.

Farmlands constitute 42.7 mln ha, that is 70.8% of the territory of Ukraine (StateGeoCadastre). 41.0 out of 42.7 mln ha (that is 96%) are under the moratorium and cannot be traded. The large chunk of this land is in private ownership (30.8 mln ha), the farmland that hasn't been privatized constitutes 10.7 mln ha (in accordance with monthly land review of StateGeoCadastre). Large agricultural enterprises hold about 6 mln ha of farmland combined (Nizalov, 2017), the rest of the privatized land is distributed across the population.

Without taking into account the shadow schemes for transferring property rights, the only way of using the land that under the moratorium for non-farmers is to lease it out. According to the State Service of Ukraine for Geodesy, Cartography and Cadastre as of January 1, 2018, 4.9 million land lease agreements were set that cover 19 mln ha (both state and collective). The average rental price is about $50 per ha for a private farmland and about $107 for a state land (according to the StateGeoCadastre data).

Lifting the moratorium will allow to conduct farmland purchase transactions and create every possibility to use land as collateral. According to the most conservative estimates, liberalization of the land market will increase the price of agricultural land at least by 3.5 times and rental price accordingly; land collateralization will facilitate the access to financing, overall expanding lending by $25 bln (Nizalov, 2017).

Chapter 3

LITERATURE REVIEW

Irving Fisher conventionally is considered as the closest predecessor of the modern view on the financial sector. His contemplation of the Great Depression roots resulted in the debt deflation theory, which maintains that recessions emanate from deflation, which, in its turn, leads to the increase of the real value of debt. The starting point of Fisher's reasoning (1933) is an assumption of the existence of state of over-indebtness. On this basis, he successively deduced the sequence of developments that inevitably lead economy to a recession after a burst of the debt bubble. Debt liquidation, followed by the decrease of the money velocity proceeds in the price level decline, compounded by going down of the business value, results in falling in output, unemployment and other attributes of recession. These inferences, derived within the confines of the general equilibrium theory, constitute Fisher's standpoint on causes of Great Depression and makes him relate to the contemporary view on the financial sector.

In a similar manner John Maynard Keynes attached the importance to financial markets. Five years before his General Theory came in light, the spotlighted crisis in Germany became the object of Keynes' (1931) close attention and origins of its propagation were found in the banking sector. Recession is inevitably accompanied by a fall in prices for all types of assets, including real estate. Banks, playing the role of intermediators between lenders and borrowers, may face the embarrassment with "guarantee" as a consequence of the asset price decline, which is a threat for the whole financial system. Keynes' position on the role of asset worth fall in downturn amplification inline and to a great extent anticipates the view of a more recent economist on the financial sector.

The development of the idea of financial accelerator during the following sixty years was marked only by partial equilibrium models. The principle that moral hazard phenomena may result in additional spending in the construction of contracts known as costly state verification was developed by Townsend (1979). The moral hazard problem is caused by the information asymmetry in the lender-borrower relationship of two risk-neutral economic agents. Information about the financial state of the borrower is distributed not equally. The borrower knows if he will be able to repay the loan, whereas the lender not. This creates additional costs associated with the process of monitoring. The monitoring costs largely depend on the characteristics of the economic agents that was discussed by Holmstrom and Tirole (1997) along with problem of double moral hazard. This fact serves as a precondition for the existence of external finance premium which imply the bank lending channel of the monetary policy transmission.

The important feature of the nowadays macroeconomic general equilibrium modeling, which address the issue of business cycle entangled by financial factors, is integrating monopolistic competition to at least one market in the developing framework. Forasmuch as monopolistic competition means the presence of price frictions, several techniques for price setting were introduced. The prevalent pricing in the modern model building is setting the price according to Calvo (1983). In economic setup of the "Calvo world" there is a multiplicity of firms that produce non-homogeneous products, which can be substituted by products of other firms. The stickiness is achieved by the existence of probability that a firm will be unable to reset the price in the next period, so all firms optimize their behavior taking into account the flow of forthcoming periods, where the price may be not adjusted.

On the contrary, pricing that rests on the assumptions proposed by Rotemberg (1982) deals with the concept of adjustment costs. Price increase associated with additional real costs for firms, such that firms with the same level of costs may increase its product's price at the expense of identical costs. An interesting feature of Rotemberg and Calvo stickiness is that they yield the same results under the first order Taylor expansion (which the current work is limited to) and have the same welfare costs (Nistico, 2007). However, the later pertains only to the case of the efficient steady state (Lombardo, 2008).

The work of Blanchard and Kiyotaki (1997) affirmed a monopolistic competition as the necessary basis for general equilibrium modeling. Paper questions to which extend the setup including monopolistic competition can explain fluctuations in aggregate demand comparison to the setup with perfect competition. The inferences the authors arrive at are very consonant with Keynesian ones. Monopolistic competition compounded by other market imperfections results in lower output and can generate fluctuations that are unobtainable under the assumption of perfect competition.

A new stage of evolution of the concept of financial frictions is usually associated with works of Bernanke, Gertler, Gilhrist. The first attempt of constructing the general equilibrium model with the financial sector often refers to Bernanke and Gertler's (1989) OLG neoclassical model that studies output fluctuations caused by changes in credit worthiness of firms and households. Integration of financial frictions in the form of the external finance premium into the general equilibrium setup is an attempt to make theoretical framework relevant and coherent with observable results of monetary regulations. This necessity was induced by numerous empirical papers that were seeking the explanation for "black box" effect of the monetary policy. An example of such a work is Bernanke and

Gertler's (1995), who tried to rationalize the output response to monetary shock through bank lending and balance sheet channels.

Bernanke, Gertler and Gilhrist (1996), trying to explain the amplification mechanism or "how small shocks generate large fluctuations", established the concept of "financial accelerator" and discuss its implication. The idea of the external finance premium, a natural consequence of asymmetric information, was reflected in DSGE by Bernanke, Gertler and Gilhrist (1999), having made this setup ubiquitous and engendered the whole generation of DGSE models with financial frictions.

External finance premium could be described as "price" financial friction because it arises from a higher lending rate compared to the case of perfect information. However, there is a particular subset of DSGE models that implement "quantitative" type of financial frictions incarnated in the borrowing constraint. In such models the size of a loan available for economic agent is restricted by the value of assets it possesses.

Kiyotaki and Moore (1997) built a deterministic general equilibrium model with the collateral constraint and described the propagation mechanism. Durable goods, defined as land, designed in fixed supply and serve at the same time as a factor of production and as a mean to secure a loan. Some negative shock causes the net worth of firms to fall, that, in its turn, decreases demand for land and driving its price down. The land price drop amplifies the fall of net worth of firms and, in this manner, the effect of negative shock propagates. The work of Kiyotaki and Moore originate the line of DSGE models, which inherent the mentioned transmission mechanism.

Another brick in the credit cycles theory was laid down by Kyiotaki (1998) in his "Credit and Business Cycles". Having no rationale for the output movements intimated by the real data, the Real Business Cycle models proved its inability to explain deep, protracted fluctuations. Kyiotaki insists that there is neither internal mechanism nor exogenous shocks that may explain the observable dynamics. He takes a shot at the data substantiation by constructing two models with financial imperfections. Borrowing constraints tend to expound output decline persistence, observed from the data, and interaction of the fixed capital with collateral constraints may explain both persistence and amplification.

Kocherlakota (2000) continues the stream of research initiated by Kyiotaki. As the previous researchers suggest, he emphasizes that size, persistence and asymmetry of output responses cannot be embedded in the RBC framework. Summarizing the previous developments, Kocherlakota models the economy with the limited contract enforceability that implicate borrowing constraints and shows that such frictions give rise to the quantitatively significant amplification of shocks.

While the latter researchers made an attempt to study the effect of the monetary and real shocks in economy with collateral constraints through introduction of the price and labor frictions, Cordoba and Ripoll (2002) presented an ingenious alternative. The model exploits the Kiyotaki-Moore economy where heterogeneous agents have to hold enough money for transactions one period before the transaction take place. This cash-in-advance constraints compounded by the collateral type of borrowing constraints generate a powerful source of the shocks propagation. The Cordoba and Ripoll's model allows monetary shock through money injection via open market operations and found that the framework spawns persistent output fluctuations as result of this shocks. Degree and duration of the fluctuations depends on the extent to which credit market imperfections tend to amplify initial output increase/decline. The effect asserted to be weaker the debt indexation provided.

The model of Cordoba and Ripoll (2002) produced an unorthodox explanation of the output behavior under the influence of shocks. Interaction of the collateral and cash-in-advance constraints shape the GDP response justifying its hump form. Also, the authors pointed out on the asymmetry of the constraint bindingness. The asymmetry take place because full indexation possible only as result of monetary policy tightening. In this sense the paper anticipated inferences of Iacoviello who wrote several influential papers on the asymmetry of collateral constraints in the beginning of 2010's.

Ireland (2004) scrutinized the role of the monetary and productivity shocks in the business cycle fluctuations. With the aim of taking the model to the data he applied the full information maximum likelihood technique to the New-Keynesian general equilibrium model. That is the largest DSGE model estimated with FIML approach and it incorporates monetary, technological and preference disturbances. Based on the US postwar data, Ireland found a limited impact of TFP shocks on the macroeconomic dynamics.

Iacovello (2005) continues the tradition of Kiyotaki and Moore in many respects, yet introduce several features that made this framework a "workhorse" DSGE model for this type of financial frictions. Heterogeneity among consumers and borrowers along with nominal debt assumption incorporated in New-Keynesian setup allows to capture consumption-asset price comovement (houses considered as collateral) and brings model's dynamic close to the real data. In other aspects, the author follows Kiyotaki and Moore (1997) such as fixed asset supply, no imperfections in the banking sector, etc leading to further endeavors.

The behavior of The European Central Bank and The Federal Reserve System during the 2001 crisis was compared by Christiano, Motto and Rostagno (2007). They built medium-scale dynamic stochastic general equilibrium model with nominal rigidities on the labor and goods market and real rigidities represented by quadratic adjustment costs. Households, entrepreneurs, capital producers and banking sector constitute the core of the model and interaction between two of them, namely, entrepreneurs and banks generates financial frictions. A wide range of the stochastic processes (fifteen) that contribute to the data explanation in varying degree. The model was estimated twice based on the US and EU data with the Bayesian approach in order to address the question if the CEB could perform better during the 2001 downturn. The estimation alludes that the effect of the ECB policy actions was marked by higher persistence in the discussing period. It is stated that the non-identical structure of the economies and different sources of the decline, complicated by the differences in the socks' duration make direct comparison of the ECB and Fed of little sense. Suchwise, according to Christiano, Motto and Rostagno the prices in the US economy are more flexible, the shocks that gave rise to the 2001 recession had taken place in US one year before than in EU and was accompanied by the moderate positive technological shock (in contrast with the European case). Finally, it was shown that ECB that follows the Fed's monetary policy could have cause higher inflation and lower output.

Iacovello and Neri (2010) addressed the question of housing market determinants in the similar fashion. For these needs they extended the DSGE with the collateral constraint in several directions. On the supply side of the economy there was introduced a housing sector (previous models included only the demand side of the housing market). House producers are separated as particular economic agents, who produce with constant returns to scale production function (with labor, capital, land and intermediate input) and operate at the competitive market. All production sectors experience slow technological growth. Nominal rigidities on the labor market also implemented in order to explain fluctuations in the house market and how they could be transmitted to other sectors of economy. They concluded that the house price growth outruns technological progress in housing construction and that wage rigidities on the house market (which is competitive) matters. Other important finding is that house preference shocks have an important role in expansion of the US economy. The paper of Iacovello and Neri made a great contribution to analyzing the housing market spillovers and the framework is extensively used by European central banks and IMF.

Gerali (2010) further developed DSGE with borrowing constrains by introducing monopolistic competition in the banking sector. The model is estimated for Euro zone and shows that a great part of fluctuations during '08 crisis can be explained by shocks in the banking sector. The other implication is that the imperfect banking sector differently affects the magnitude of fluctuations caused by monetary and technological shocks.

As the productivity shock affects output directly, it proved to be unable to change the asset prices significantly and therefore abet the shock amplification. This fact impugns the ability of the credit cycle theory to contribute in the explanation of macroeconomic dynamics, moreover, it makes the business investments - land prices comovement puzzling. Liu, Wang and Zha (2013) posits that preference shocks may substantially affect the asset prices, resolving the puzzle. They built a model a-la Iacoviello (2005) where land plays the role of the collateral for borrowing economic agents and is a source of utility for the households (the reason for the substitution of housing with land is that housing prices are mostly driven by the land prices). They perform several robustness checks and found a firm link between the land price and investments.

Large-scale DSGE model with borrowing constraints of Peru was developed by Leon (2016). It is an attempt to reflect the structure of emerging economies by introducing a small open economy framework with partial dollarization, sticky prices and wages. The gist of the model constitutes the examination of demand

and supply side factors of credit expansion. Structurally Leon's large-scale small open emerging economy in the greatest extent reflects characters of the Ukrainian economy.

The attention of Guerrieri and Matteo (2017) is focused on the efficiency of various policies in economies with collateral constraints when the constraints are asymmetrically binding. The authors underscore that the fact that constraints are not binding at the "good times" and binding "at bad times" can entail a significant spillover from the house market; debt relief policy can enhance the spillovers. Vital importance is attached to binding constraints in acceleration of Great Depression.

In a typical paper dealing with borrowing restrictions there is an asset under consideration and macroeconomic implications that this asset may induce, under certain assumptions, form the basis of a research. Studying more than one means of collateral involved case can be regarded as a side stream of research. However, a question of an instant collateral increase, compounded by the issue of mutual collateral price dynamics during the business cycle is not deprived of some scientific curiosity and has some originality.

Chapter 4

THE MODELS

To a large extent I follow Iacoviello (2005). The model is constructed in discrete time and assuming infinitely-living economic agents. The economy consists of patient households, impatient households and entrepreneurs. Patient and impatient households differ in the value of discount factor and identical in other respects, they draw utility from consumption and housing and disutility from work. Patient households lend money to impatient households and entrepreneurs. Important extension is that both types of households get rent from the possession of land, but do not draw utility from it.

Entrepreneurs produce wholesale goods and draw utility from consumption. The inputs are capital (that can be adjusted from final goods), labor (supplied by both types of households), land and houses. Firms sell their goods to retailers on competitive market and buy labor on perfect market as well.

In the models, retail firms are run by patient household. They differentiate wholesale goods without costs and vend them to aggregators, who produce final goods. The central bank follows the Taylor rule. Both land and houses supplies are fixed.

4.1 Initial model

There are two principle differences between initial and modified models: (1) presence of free land market (2) possibility to use land as collateral.

4.1.1 Patient households

Patient households maximize the horizon of expected utilities from final goods consumption, stock of housing and disutility from work. Following Iacoviello, I use the logarithmic form of the utility function which a special case of the Constant Relative Risk Aversion (CRRA) utility function. The objective function is:

$$U^P = E_0 \sum_{t=0}^{\infty} {\beta^P}^t \left(\ln c_t^p + j_t \ln h_t^p - \frac{{L_t^P}^\eta}{\eta} \right) \quad (1)$$

where t – time index, β^P - discount factor, c^P and h^P – consumption of goods and housing respectively, L^P – working hours, η – labor supply aversion, E – expectation operator, j – housing preference parameter that follows AR(1) process:

$$j_t = j_{t-1}^{\rho_h} \exp(\varepsilon_{h,t}) \ , \ \varepsilon_{h,t} \sim N\ (0, \sigma_h) \quad (2)$$

Expenditures in each period consist of consumption, expenses on the change in the stock of housing and borrowing repayment. This can be finances by borrowings, labor incomes, rents from land, profits (as patient households run retail firms which operate on the market with monopolistic competition) and lump-sum net budget transfers. In the flow of fund all the variables are specified in real terms:

$$c_t^P + q_t^h (h_t^P - h_{t-1}^P) + R_{t-1} \frac{b_{t-1}^P}{\pi_t} \leq b_t^P + w_t^P L_t^P + r_t^P Z^P + F_t + T_t^P \quad (3)$$

where q^h - real price of house, w^P – real wage, r^p – real land rent of patient consumer. F denotes lump-sum profits from running retail firms, T – lump-sum government transfers, R – nominal interest rate, b^p – borrowings, π - inflation.

The difference from Iacoviello (2005) is the presence of rent payments in the budget constraint. Households hold some agricultural land and have nothing else to do (before the lifting of the moratorium on the land sale) but lease it out and get rent payments in return. Note, that Z^P (amount of land) is exogenously given and not a subject of optimization. Thus, patient consumers choose consumption, number of working hours, housing stock and borrowing.

Combined first order conditions can give us quite standard for this type of DSGE models equations of the labor supply, housing demand and Euler equation which could be found in Appendix A.

4.1.2 Impatient households

Impatient households have lower value of discount factor (compared to patient ones) that endogenously defines them as borrowers. Impatient as well as patient households derive utility from consumption c^I, houses h^I and labor L^I (disutility):

$$U^I = E_0 \sum_{t=0}^{\infty} {\beta^I}^t \left(\ln c_t^I + j_t \ln h_t^I - \frac{{L_t^I}^\eta}{\eta} \right) \tag{4}$$

Expenditures on houses, consumption goods and loan repayment can be financed by new borrowings b^I, wages w^I from labor purveying and rent r^I from lands possessing(Z^I). Budget constraint has the following form (the same as for patient):

$$c_t^I + q_t^h (h_t^I - h_{t-1}^I) + R_{t-1} \frac{b_{t-1}^I}{\pi_t} \leq b_t^I + w_t^I L_t^I + r_t^I Z^I + T_t^I \tag{5}$$

As it was mentioned, impatient household discount future utility faster than patient due to low β. In economy inhabited by heterogeneous agents (in terms of β), this heterogeneity will inevitably make borrowers of those one with lower discount factor. So impatient households' optimization leads to borrowings that makes them "impatient" in the full sense of the word.

Borrowings of impatient households cannot exceed the expected future value of their assets:

$$R_t b_t^I \le m_t \pi_{t+1} q_{t+1}^h h_t^I \tag{6}$$

where m^I is loan-to-value ratio. I made LTV ratio stochastic similar to Gerali (2009) and it follows AR(1) process:

$$m_t = m_{t-1}{}^{\rho_m} \exp(\varepsilon_{m,t}) \,, \;\; \varepsilon_{m,t} \sim N\,(0, \sigma_m) \tag{7}$$

To make the model clearer is also useful to draw distinction between the housing stock and the land stock in the setup. Households get utility from housing, can buy and sell houses on the housing market (but not rent) and use as collateral. Land, on the contrary, is not in the utility function, can be leased (and bring rent payments), cannot be traded or collateralized. However, the latter two assumptions will be relaxed in succeeding sections.

Optimizing of (5) with respect to (6) and (7) we can obtain labor supply and house demand for impatient household (Appendix B).

4.1.3 Entrepreneurs

In this setup firms are separate economic agents and draw utility from consumption only. They have lower discount factor than patient households and it defines their behavior as borrowers.

$$U^E = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E \tag{8}$$

In order to finance their consumption, entrepreneurs produce wholesale goods. Compared to Iacoviello (2005) I introduced agricultural land as an additional factor of production:

$$Y_t = A_t K_{t-1}^{\mu} h_{E,t-1}^{v} (Z_E^{\varphi} Z_P^{d} Z_I^{1-\varphi-d})^{u} (L_{P,t}^{\alpha} L_{I,t}^{1-\alpha})^{1-\mu-u-v} \tag{9}$$

The production function is constructed in spirit of Iacoviello in the way leading to analytical solutions. Firms produce output with capital K, houses h^E, land of all types of economic agents Z_p, Z_I, Z_E and labor of patient L^P and impatient L^I household. μ stands for capital share in output, v for house share in output, u for land share in output. Wages and rents are distributed according to the shares of economic agents (φ, d, α). The total factor productivity follows AR(1) process:

$$A_t = A_{t-1}^{\rho_A} \exp(\varepsilon_{A,t}), \ \ \varepsilon_{A,t} \sim N(0, \sigma_A) \tag{10}$$

Entrepreneurs maximize their utility with respect to entrepreneur's flow of funds. Incorporation of land requires two additional (compared to Iacoviello (2005)) terms (rent payments to patient households and rent payments to impatient households):

$$c_t^E + q_t^h (h_t^E - h_{t-1}^E) + R_{t-1} \frac{b_{t-1}^E}{\pi_t} + w_t^I L_t^I + w_t^P L_t^P + r_t^I Z^I + r_t^P Z^P + I_t + \xi_t^K \leq \frac{Y_t}{X_t} + b_t^E \tag{11}$$

Firms spend their incomes from production and borrowings on consumption, housing, borrowings repayment, land and labor factor payments to patient and impatient households. Labor and land markets are modeled as competitive, so the factor owners earn marginal product. In every period, δ share of capital depreciates and capital stock can be replenished by investments I:

$$I_t = K_t - (1 - \delta) K_{t-1} \tag{12}$$

Capital adjustment ξ^K costs have quadratic form, such that in steady-state they are equal to zero:

$$\xi_t^K = \frac{\psi}{2\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1} \tag{13}$$

In addition, entrepreneurs are limited in borrowings in the same manner as impatient households:

$$R_t b_t^E \leq m_t \pi_{t+1} q_{t+1}^h h_t^E \tag{14}$$

where m is stochastic LTV ratio that follows AR(1) process:

$$m_t = {m_{t-1}}^{\rho_m} \exp(\varepsilon_{m,t}) \ , \ \varepsilon_{m,t} \sim N\,(0, \sigma_m) \tag{15}$$

Maximization of (8) with respect to (9), (11), (12), (13) and (14) describe demand side of the labor markets, optimal investment schedule and firms' demand for houses (Appendix C).

4.1.4 Other agents

Retailers and Central Bank constitute the rest of the model and exactly matche to the corresponding section in Iacoviello (2005). There is a continuum of retailers i and mass 1 that buy intermediate homogeneous goods Y for price P^W, differentiate them without cost and sell it at imperfect market with markup X at price P. Aggregate price index $P_t = \left(\int_0^1 P_t(i)^{1-\varepsilon}\, di\right)^{\frac{1}{1-e}}$ corresponds to aggregate output $Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}}\, di\right)^{\frac{\varepsilon}{\varepsilon-1}}$, and it can be shown that each retailer faces $Y_t(i) = (P_t(i)/P_t)^{\frac{\varepsilon}{\varepsilon-1}} Y_t$.

Given standard Calvo pricing with probability of price resetting equal to 1-θ, each firm maximize discount expected profits with respect to optimal price P*:

$$\sum_{k=0}^{\infty} \theta^k E_0 \left(\beta^P \frac{c_t^E}{c_{t+k}^E} \left(\frac{P_t^*(i) - P_t^w}{P_t}\right) Y_{t+k}(i)\right) \qquad (16)$$

Optimization of (16) coupled with evolution of price level $P_t = \left(\theta P_{e-1}^{\varepsilon} + (1-\theta) P_t^{*\,1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}$ yields the standard New-Keynesian forward-looking Philips Curve.

The Central Bank follows the Taylor rule

$$R_t = (R_{t-1})^{r_R} (\pi_{t-1}^{1+r_\pi} \left(\frac{Y_{t-1}}{Y}\right)^{r_Y} \overline{rr})^{1-r_R}\, e_{R,t} \qquad (17)$$

where is a monetary policy shock, that follows AR(1) process:

$$e_{R,t} = e_{R,t-1}{}^{\rho_e} \exp(\varepsilon_{R,t}) \qquad (18)$$

4.1.5 Equilibrium

The general equilibrium is characterized by equilibria on the good, labor, financial and housing markets. The model assumes binding collateral constraints, so impatient households and entrepreneurs borrows up to the limit. The definition of all flows between the economic agents also requires two of three budget constraints (by the virtue of Walras law).

The model describes private (no government spending) closed (no export/import) economy, so final output can be either consumed by entrepreneurs, patient households and impatient households, or adjusted in the form of investments by entrepreneurs. Equlibrium on the good market is described by equation (19).

$$Y_t = c_t^P + c_t^I + c_t^E + I_t \tag{19}$$

The market clearing condition in the labor market in fact combines market clearing condition in the labor market for patient households and in the labor market for impatient households.

$$L_t^{Demand} = L_t^{Supply} \tag{20}$$

The sum of borrowings is equal to zero, i.e. the sum of borrowings is equal to the sum of savings (negative borrowings) in the economy.

$$b_t^P + b_t^I + b_t^E = 0 \tag{21}$$

Supply on the housing market is fixed and not depreciates.

$$h_t^P + h_t^I + h_t^E = \overline{H} \tag{22}$$

4.2 Modified model

Let us move to the modified model that simulates the changes in the economy associated with lifting the moratorium on the land sale. In this model I allow land to trade and to use as collateral. This affects all economic agents and the present section briefly describes the changes.

4.2.1 Patient households

Patient households consume goods and housing service, work, lend money and choose the amount of land to own since the land trade is no longer prohibited. Agricultural land delivers no utility, so the utility function stays unchanged:

$$U^P = E_0 \sum_{t=0}^{\infty} \beta^{P^t} \left(\ln c_t^p + j_t \ln h_t^p - \frac{{L_t^P}^\eta}{\eta} \right) \quad (23)$$

$$j_t = j_{t-1}^{\rho_h} \exp(\varepsilon_{h,t}) \text{ , } \varepsilon_{h,t} \sim N\,(0, \sigma_h) \quad (24)$$

The budget constraint was modified. The third term reflects that households can buy and sell land. And time subscript of Z (in the income part of the budget constraint) indicates that rents are obtain from the land the amount of which can be optimized.

$$c_t^P + q_t^h(h_t^P - h_{t-1}^P) + q_t^Z(Z_t^P - Z_{t-1}^P) + R_{t-1}\frac{b_{t-1}^P}{\pi_t} \leq b_t^P + w_t^P L_t^P + r_t^P Z_{t-1}^P + \\ + F_t + T_t^P \quad (25)$$

where q_t^z is land price and $(Z_t^P - Z_{t-1}^P)$ is additional land acquired in period t.

Maximization yields five first-order conditions that could be combined to four equations. They are labor supply, housing-consumption ratio (housing demand) and Euler equation and land supply (Appendix D). First three exactly replicate results from the initial model. The fourth one stands for land-consumption ratio and arises due to additional choice variable (land).

4.2.2 Impatient household

Utility function of impatient household duplicates (4):

$$U^I = E_0 \sum_{t=0}^{\infty} \beta^{I^t} \left(\ln c_t^I + j_t \ln h_t^I - \frac{{L_t^I}^\eta}{\eta} \right) \quad (26)$$

subject to a constraint which takes into account land trade (the same as for patient households):

$$c_t^I + q_t^h(h_t^I - h_{t-1}^I) + q_t^Z(Z_t^I - Z_{t-1}^I) + R_{t-1}\frac{b_{t-1}^I}{\pi_t} \leq b_t^I + w_t^I L_t^I +$$

$$+ r_t^I Z_{t-1}^I + T_t^I \tag{27}$$

Borrowing constraint constitute the essence of the models, engendering shock amplification. While the initial model replicates the borrowing constraint from Iacoviello (2005), in the modified model I allow land to be used as a mean of collateral.

$$R_t b_t^I \leq m_t \pi_{t+1}(q_{t+1}^h h_t^I + q_{t+1}^Z Z_t^I) \tag{28}$$

$$m_t = m_{t-1}{}^{\rho_m} \exp(\varepsilon_{m,t}), \ \ \varepsilon_{m,t} \sim N(0, \sigma_m) \tag{29}$$

Maximization of the utility function subject to the budget and collateral constraints provides labor supply, houses-consumption relation and land-consumption relation. The equations are reported in Appendix E.

4.2.3 Entrepreneurs

Entrepreneurs draw utility from consumption that is equivalent to (8):

$$U^E = E_0 \sum_{t=0}^{\infty} {\beta^E}^t \ln c_t^E \tag{30}$$

Production is performed with capital, houses, land and labor. Now the amount of land is a choice variable:

$$Y_t = A_t K_{t-1}^{\mu} h_{E,t-1}^{v} (Z_{E,t-1}^{\varphi} Z_{P,t-1}^{d} Z_{I,t-1}^{1-\varphi-d})^u (L_{P,t}^{\alpha} L_{I,t}^{1-\alpha})^{1-\mu-u-v} \tag{31}$$

$$A_t = A_{t-1}^{\rho_A} \exp(\varepsilon_{A,t}), \ \ \varepsilon_{A,t} \sim N(0, \sigma_A) \tag{32}$$

The budget constraint is extended for the possibility of land purchase and takes into account rent payments in favor of patient households and impatient households:

$$c_t^E + q_t^h(h_t^E - h_{t-1}^E) + q_t^Z(Z_t^E - Z_{t-1}^E) + R_{t-1}\frac{b_{t-1}^E}{\pi_t} + w_t^I L_t^I + w_t^P L_t^P +$$

$$+ r_t^I Z_{t-1}^I + r_t^P Z_{t-1}^P + I_t + \xi_t^K \leq \frac{Y_t}{X_t} + b_t^E \tag{33}$$

Capital flow and adjustment costs a left without changes without changes and correspond to (12) and (13). Collateral constraint is modified in the same manner as impatient households'. Entrepreneurs are allowed to secure their loans not only with houses, but also with land.

$$R_t b_t^E \leq m_t \pi_{t+1}(q_{t+1}^h h_t^E + q_{t+1}^Z Z_t^E) \tag{34}$$

$$m_t = m_{t-1}{}^{\rho_m} \exp(\varepsilon_{m,t}) \ , \ \varepsilon_{m,t} \sim N\,(0, \sigma_m) \tag{35}$$

Entrepreneurs' FOCs result in labor demand, demand for land, optimal investment schedule, land-consumption and housing consumption relation reflected in Appendix F.

4.2.4 Other agents and equilibrium

The rest of the model was remained unchanged. Calvo pricing on the retail level implies Philips curve analogous to the previous. The central money authority follows Taylor rule analogous to (17).

Market clearing conditions are the same as for the initial model and can be described by equations (19) - (22). The land market implies the fixed land supply, so I introduce additional condition:

$$Z_t^P + Z_t^I + Z_t^E = \bar{Z} \tag{36}$$

Chapter 5

SOLUTION AND PARAMETERIZATION

The initial model includes 22 endogenous variables, 23 parameters and 4 variables with exogenous dynamics. The modified model was extended for four variables (land of three groups of economic agents and land price) comprising 26 endogenous variables and 5 markets.

I transformed all the variables from absolute values into the form of relative deviations such that $\tilde{x}_t$ denotes the percentage deviation of variable x from the steady state value x at time t. The procedure of the log-linearization usually requires rewriting the equations in form of logs as

$$\tilde{x}_t = \ln x_t - \ln x \qquad (37)$$

and taking exponent from the both sides. Then transformation takes the form of first order Taylor expansion:

$$x_t = e^{\ln x + \tilde{x}_t} = e^{\ln x} e^{\tilde{x}_t} = x e^{\tilde{x}_t} \approx x(1 + \tilde{x}_t) \qquad (38)$$

In this fashion initial model was log-linearized around growthless steady-state with zero inflation and reduced to the thirteen equations that describe dynamics of thirteen endogenous variables and four equations with exogenous dynamics. Steady-states for the initial model could be found in Appendix G. The log-linearized version of the initial model is reflected in Appendix H. Appendix I and Appendix J include steady-states and the log-linearized version of the modified model. The models were boiled down to the form suggested by Uhlig (1995), such that the method of undetermined coefficients could be applied manually or using Uhlig toolkit, however, Dynare copes with this task excellently.

To derive implications from the models' properties 23 parameters should be chosen. The parameters can be divided into five groups in accordance with the method of determining their value.

The first group consist of parameters that can be calibrated from the Ukrainian data. These are parameters of Cobb-Douglas production function, income shares of economic agents in production. The second group constitutes parameters that can be set based on the steady-state relationship: weight of houses in the utility function, steady-state markup, steady-state loan-to-value ratio. A number of parameters I adopt from the other researches such as the discount factors for impatient households and entrepreneurs. They cannot be calibrated in a straightforward way and seem to be the subject of the distinct research, which is out of the scope of the present work. The fourth group covers the parameters of the Taylor rule. The fifth group includes capital adjustment costs, the degree of Calvo stickiness, parameters of autocorrelation and shocks' standard deviations. They are estimated by the MLE technique.

In the process of calibration, I am largely guided by the works of Cooley and Prescott (1995), Gomme and Rupert (2007), who describe several approaches for the parameters choice. Under the assumption of perfect competition on the input markets, input owners earn marginal products of corresponding factors of production. First order conditions of the entrepreneurs' maximization problem coupled with constant returns to scale production function imply that overall output can be expressed as a sum of flows to the input purveyors:

$$Y = \mu Y + vY + uY + (1 - \mu - u - v)Y \tag{39}$$

The first term corresponds to payments to capital owners, the second one - to housing owners, the third term pertains to income received by land proprietors and the last one is a wage bill. The most straightforward way to obtain the sought-for output shares relies on the GDP data. Based on the Ukrainian GDP by income statistics for 2016 provided by UKRSTAT, and allowing the ambiguous income (mixed profits) to be distributed between factor owners in the same fractions as the unambiguous income, I set labor share equal to 0.7. The marginal product of land is estimated as 200$ per ha and assuming 20 mln ha of farmland in the formal production I picked u=0.03, so capital and housing shares have 0.27 combined. I chose housing share equal to 0.02 that is in accordance with Iacoviello (2005), leaving 0.25 to capital share. Depreciation rate is determined as a ratio of capital depreciated to overall capital stock. I used the steady-state property that depreciation is equal to the Investment-Capital ratio and based on the data provided by UKRSTAT I calculated depreciation as 13% yearly, so I choose δ=0.031.

According to the NBU study Nikolaichuk, Lepushynskyi and Hrui (2017) the equilibrium interest rate for Ukraine is 2%, so I picked the discount factor for impatient households as the reciprocal of the rate, that, for quarterly data is 0.995. Unfortunately, the economic field in Ukraine is marked by the absence of empirical studies on the matter of discount factors estimation for different types of economic agents. Papers of Lawrance (1991) and Samwick (1997) suggest that the value of the discount factors for the groups of interest should lie between 0.91 and 0.99, so I picked 0.98 for entrepreneurs and 0.94 impatient households (for comparison, Iacoviello (2005) set β^I=0.95 and β^E=0.98).

I assign η =2 to the Frisch labor supply elasticity which corresponds to spending of 1/3 of time endowment on work. In the α parameter choice I and take the results from Iacoviello (2010) and assign 64% of all labor income to patient households. The part of land rental payments received by entrepreneurs constitute 84% of all rental payments (see Nizalov), so φ and d are 0.84 and 0.07 correspondently. I slightly recalibrate this parameters for the modified version of the model and choose φ equals to 0.62 and d equals to 0.19 (see Nizalov). Recalibrated parameters for the modified are posted in the Appendix M.

The procedure of the Taylor rule parameters calibration involves the regression of the interest rate on the detrended output, inflation and the lagged value of the interest rate. In the Ukrainian reality the results obtained from such procedure can be rather questionable as the valid estimation of the Taylor rule parameters can be conducted only within the data of last few years. The results obtained I put in Table 1. The full results of the estimation can be found in Appendix K. All the calibrated parameters are presented in Appendix L.

Table 1: The Central Bank policy parameters

Description	Parameter	Value
The Taylor rule parameter of inflation response	r_π	0.5377
The Taylor rule inertia parameter	r_R	0.8559
The Taylor rule parameter of output response	r_Y	Insignif.

The rest was calibrated based on steady-state ratios. The steady-state markup value is a parameter extremely difficult to calibrate. Conventionally, the parameter is usually set between 1.05 (Iacoviello (2005)), and 1.20 (Gerali (2010), Iacoviello (2017)) and I chose it such that satisfy investment-to-output ratio. According to both NBU and UKRSTAT data investments constitute 14-15% of GDP, so the value of markup should be 1.1 in order to be consistent with the data. To maintain 0.35 (based on the NBU data) as the loans-to-output ratio of the entrepreneurs, the loan-to-value ratio was chosen equal to 0.31. Iacoviello (2005) assumes that the ratio is equal 0.89, but he suggests only commercial estate as collateral. The estimates of Christensen (2007) and Gerali (2009) are more germane and constitute 0.42 and 0.31 correspondently. To keep the loans-to-output ratio of the households equal to 0.07 (based on the NBU data) the weight of housing in the utility function was set as 0.05.

In estimations of the parameters of shocks persistent, shock standard deviations, adjustment costs, Calvo rigidity I follow Ireland (2004) which is the largest New-Keynesian model estimated with Full Information Maximum Likelihood. Once, the model is transformed into the state-space representation, the likelihood function of the observed data can be built according to Bauer, Haltom, and Rubio-Ramírez (2003).

As the model include four exogenous processes and I use data on four endogenous variables. In the procedure I use Ukrainian quarterly data 2006Q1-2016Q4 on seasonally adjusted, HP-detrended output and investment per capita, HP-detrended prices on housing and inflation. All the timeseries are used in the form of percentage deviation from the long-run steady-state.

The estimation results suggest high persistent of the financial and housing preferences shocks (all between 0.947and 0.980), and persistent of moderate magnitude of the technological shock. Estimates of σ_a= 0.0262 and σ_e= 0.0089 are significant and expectedly lower than standard deviations of the financial and preference shocks.

I estimated the capital adjustment costs at the level of 0.625. The estimate for the Calvo stickiness parameter equals to 0.34 implies that firms on average firms resets prices each 1/(1-0.34)=1.5 quarters that is somewhat in contrast with standard 4 quarters. The results of ML estimation may be found in Appendix N.

Chapter 6

RESULTS

In this section I describe the results obtained from both models and then proceed with impulse response function analysis.

Since the economy in the present work is modeled as private and closed, the expenditure side of GDP is described as the sum of consumption and investment spending. The Capital-to-Output (from the steady-state properties, Appendix G) depends only on the parameters of calibration, which are defined in the fashion that satisfies the Ukrainian data. Absent shocks, the Investment-to-Capital ratio equals to the depreciation rate, meaning that in each period the worn-out capital is replaced by investment, maintaining the capital stock fixed. Combining the Capital-to-Output and the Investment-to-Capital ratios one can deduce the Investment-to-Output ratio that is immutable across the models (as neither land nor land parameters does not enter the equation that define the ratio) and equals to 0.137 (based on the data provided by NBU or UKRSTAT it can be calculated as 0.14-0.15). The remaining part of the output is devoted to consumption.

Rental payments to patient and impatient households account for 0.5% of output in the initial model (from CRS production function) that approximately corresponds to the amount of rental payments in Ukraine (less than 1%, see chapter 2). As there is no land price in the model, I compute it as the net present value of all payments that both types of households will receive by leasing the land out. I determine the discount factor as a reciprocal to the average of the patient and impatient households' rate of time preferences. Without growth, the ratio of NPV of land possessed by households to output yields 0.14. The alternative scenario reflected in the modified model the ratio is determined on the land market. The model suggests 0.43 steady-state land value to output ratio.

Another important result is the increase of the amount of overall borrowings in the country. According to the WORLDBANK data, domestic credit constitutes 47% of GDP of Ukraine; similar estimates provide NBU splitting this amount between loans to households (7% of GDP) and to entrepreneurs (35%). The land reform allows land collateralization, thus impatient households and entrepreneurs can increase their borrowing power. New steady-state ratios show dramatic increase of the entrepreneurs' borrowings and moderate increase of the households' borrowings. The results are summarized in the Table 2.

Table 2. The steady-state ratios in the "initial" and "modified" models

Ratio	Before the Land Reform	After the Land Reform
Investment-to-Output	0.137	0.137
Borrowings-to-Output (Households)	0.08	0.1
Borrowings-to-Output (Entrepreneurs)	0.35	0.81
Land Price-to-Output	0.14	0.43

Next, I examine the properties of the models with impulse response function analysis. This provides an answer on how the magnitude of the shocks amplification will be affected after the changes implied by the land reform. The combined responses to output to the technological, monetary, preference and loan-to value shocks of the initial and modified models are reflected in Figure 2.

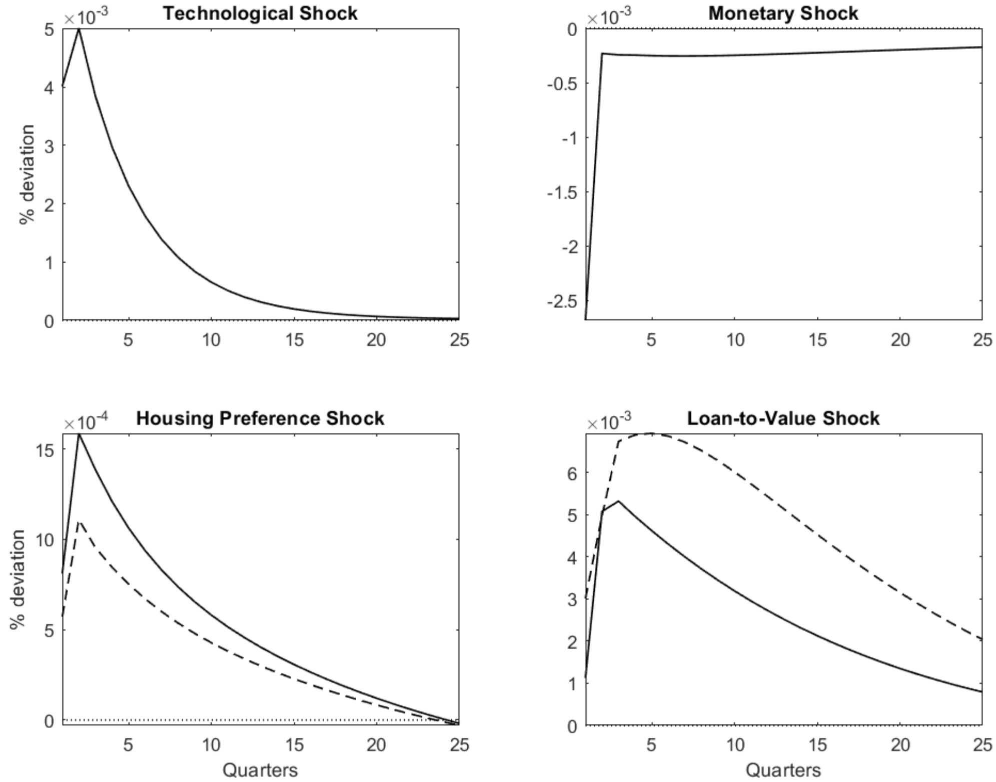

Figure 2. The IRFs of the output to one standard deviation before (solid) and after (dotted) the land reform

In a New-Keynesian DSGE with the collateral constraints a productivity shock may result in a counterintuitive impulse response function. Typically, positive technological shock leads to the inflation wane through the drop of the marginal costs of production. Decrease of the inflation level fosters the enlargement of the real burden of liabilities as result of the debt deflation. Here the financial friction comes to play. Increase of the real value of debt decreases the borrowings ability of entrepreneurs and, as result, reduce consumption, capital and housing. The latter one serves as a mean of collateral and weakens demand on the housing market that reduces price of houses and the value of collateral. Such an amplification leads to the initially negative response to the technological shock. However, the estimated model for Ukraine cannot evoke the deflation of the required amplitude, so productivity drives the output up outweighing the consequences of debt-deflation.

Monetary shock is transmitted to the real sector because of price stickiness. Nominal interest rate increase entails the hike of the real interest rate. Typical consequences of the traditional interest rate channel imply redistribution of consumption in favor of future periods and the drop of the demand on all markets including the asset market. The decrease of demand on the housing market induces prices to drop which, in turn, instigates the tightening of the borrowing constraint. Accordingly, lower value of collateral available causes the further demand drop, which in its turn further tightens collateral constraint and the shock amplifies.

Due to its high persistence the housing preference shock exerts significant effect on the macroeconomic dynamics. The positive shock leads to the higher demand for houses which drives their prices up. This means the collateral constraint easing, that is allowing higher level of borrowings. Entrepreneurs increase their capital and consumption, whereas households substitute consumption by houses. As only households are subject to preference shock, it leads to redistribution of housing wealth from entrepreneurs to households. As entrepreneurs get rid of the houses, its collateral constraint starts to tighten, whereas borrowing constraint of the impatient households have greater inertia: high demand for houses spurs house prices to rise, weakening the limitation in loans, while redistribution of housing in favor of households makes this effect prolonged.

The monetary and productivity shocks in both initial and modified models lead to the same dynamics. Land and houses behave alike with movements in the same direction with monetary and technological shocks producing a negligible difference across the models. However, the picture differs significantly in case of housing preference shock. The latter shock creates the higher oscillation of the collateral price (in comparison to other considered shocks, see Appendix O) which is consistent with Liu, Wang and Zha (2013). As housing, as a factor of production, become relatively more expensive, optimizing behavior forces entrepreneurs to acquire land and sell houses, while households do the opposite.

The financial shock has the most apprehensible effects and results in the substantial differences across the models. Mechanism is rather straightforward: the increase of the loan-to-value ratio fosters to collateral constraint easing that enhances demand on all markets. Higher demand on housing markets leads to the higher housing price which, in its turn, further amplifies shocks. In the case of LTV shock the dynamics of macroeconomic indicators is affected directly by the amount of collateral. For this reason, possibility of the borrowing against the land creates essential differences in the amplification as result of the land reform. Impulse response functions of the key variables to the discussed shocks are presented in Appendix Q.

Moving to the historical shock decomposition, I determine to what extent each shock contributes to the overall output deviations from the steady-state applying the Kalman Smoother algorithm. For this procedure I use the same data as for maximum likelihood estimation of the parameters of the exogenous processes assumed in the models, that is 2006-2016 quarterly data on inflation, output, investment and house prices.

The Kalman Smoother algorithm produces smoothed shocks and smoothed initial values. This is the best conjuncture for the shocks, given observable endogenous variables. Appendix P depicts the smoothed shocks produced by the Kalman Smoother. The cumulative impact of the smoothed shocks on output during 2006-2016 portrays Figure 3.

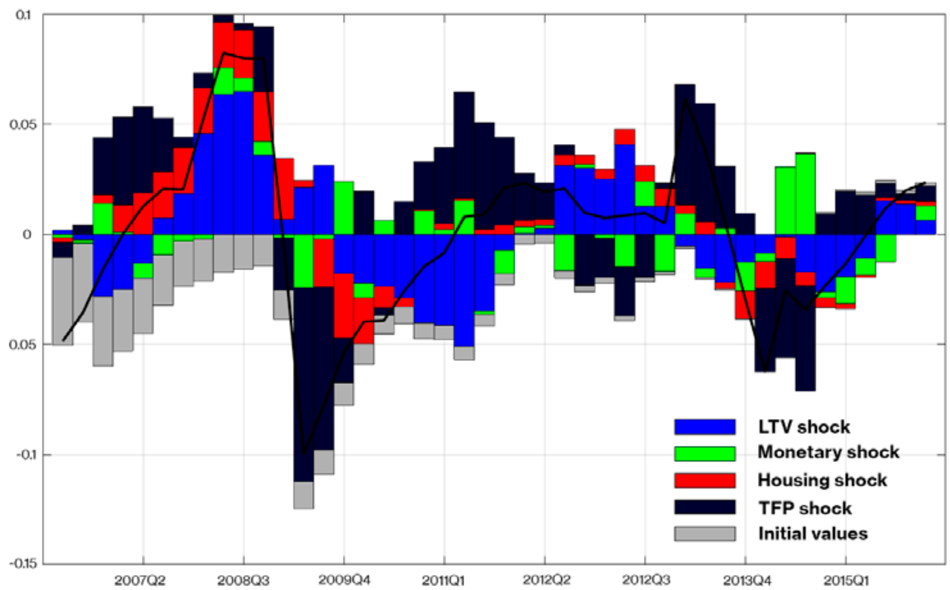

Figure 3. Historical decomposition of the output of Ukraine

The historical decomposition of the output suggests that in 2009-2011 and 2013Q3-2015Q2 output was below its steady-state level, while between the recessions, GDP was slightly above the natural level with the pick during 2013Q1. The downturn that happened in 2008 and worsened during 2009 was driven by negative TFP shock accompanied by negative housing preference shock and latter compounded by loan-to-value shock which broadly incorporated all financial factors. As the economy is modeled as closed, productivity shock may capture foreign demand shocks and domestic supply shocks. The deviations of output between 2011 and 2015 can be assigned mainly to loan-to value and total factor productivity shocks.

Finally, I proceed with counterfactual experiment. Having obtained historical decomposition of the output, I extract historical shocks produced by Kalman Smoother (Appendix P). So, a natural question arises: "what would have happened with the economy if agricultural land was tradable and collateralizable?". In other words, I took the modified model (that simulates the economy when moratorium is lifted) and made it a subject of the series of shocks produced by Kalman Smoother to obtain an alternative scenario (Figure 4).

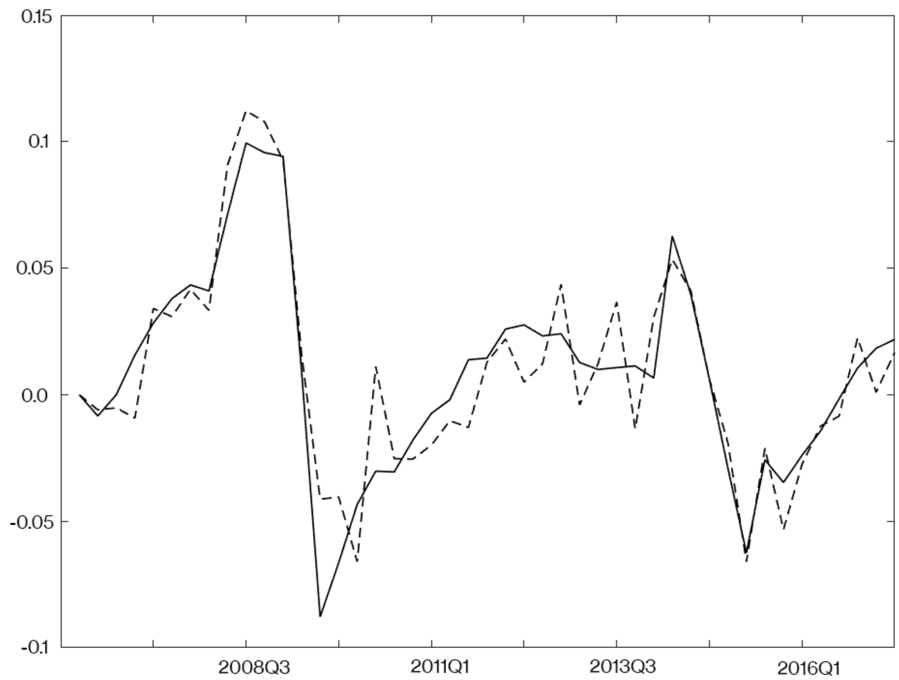

Figure 4. Counterfactual experiment. Actual output (solid) versus alternative (dotted)

The discrepancy across the scenarios is a logical consequence emanated from the fact that the initial and the modified models have different responses to shocks of similar magnitude (see Figure 2). Thus, the model after the lifting of the moratorium tends to amplify both output increase and declines caused by financial shocks, which is clearly illustrated by the output peak in 2008Q3. From the other side, the house preference shock, which significantly contributed to the GDP drop, mitigates the decline under the alternative scenario. Thus, under certain conditions, land trade and land collateralization can both contribute to the amplification and alleviate its consequences, depending on the nature of the driving force of output deviation.

Chapter 7

CONCLUSIONS

To analyze the effect of the land reform on amplification mechanism I extended Iacoviello (2005) by introducing the land and stochastic loan-to-value ratio. Land is added to the framework as another factor of production, along with capital, labor and housing. With the aim of the dynamic comparison two models were constructed. "Initial model" is constructed such that land is distributed across economic agents and is not the subject of trade or collateralization. "Modified model" allows the land trade and to borrow against its value. Most of structural parameters of the models were calibrated according to Ukrainian data. The parameters of exogenous processes were estimated with Full Information Maximum Likelihood. The main findings are following:

- Lifting the moratorium allows land trade as well as using it as additional way of securing the loans. With binding borrowing constraints additional collateral leads to the constraint easing, which increases the borrowing power of the impatient economic agents. The overall Credit-to-GDP ratio is calculated to grow twice from about 0.45 to 0.90;

- Results for land-in-production price to output ratio obtained from the models' construction differ strikingly. Steady-state ratio for this indicator in the initial model yields 0.14 and 0.43 in the modified.

- Historical shock decomposition showed that technological and financial shocks contributed to macroeconomic fluctuations to the largest extent; these shocks were estimated as highly persistent;

- The land collateralization showed the significant effect on the amplification magnitude in the case of loan-to-value shock as the amount of collateral affects the dynamics directly. Monetary and productivity shocks were attributed by negligible changes in amplification associated with the counterfactual economy with the land reform implemented;

- The counterfactual experiment suggests that the 2009 decline could be mitigated as it was partially caused by the housing preference shocks, whereas the expansion that preceded the recession could be amplified since it was the result of the financial shocks.

Overall, the main contribution of the present work is to give a quantitative assessment of the macroeconomic implications of the land market emergence in Ukraine with focus on the credit cycle fluctuations, where tradable land can potentially be used as means for extending collateralized credit.

WORKS CITED

Bernanke, Ben S., and Mark Gertler 1989. "Agency costs, net worth, and business fluctuation." *American Economic Review* 79.1: 14-31.

Bernanke, Ben S., and Mark Gertler 1995. "Inside the black box: the credit channel of monetary policy transmission." *Journal of Economic perspectives* 9.4: 27-48.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist 1998. "The financial accelerator in a quantitative business cycle framework". No. w6455. *National Bureau of Economic Research.*

Blanchard, Olivier Jean, and Nobuhiro Kiyotaki 1987. "Monopolistic competition and the effects of aggregate demand." *The American Economic Review*: 647-666.

Calvo, Guillermo A. 1983. "Staggered prices in a utility-maximizing framework." *Journal of monetary Economics* 12.3: 383-398.

Motto, Roberto, Massimo Rostagno, and Lawrence J. Christiano 2008. "Financial Factors in Business Cycles." *2008* Meeting Papers. No. 52. *Society for Economic Dynamics.*

Cooley, Thomas F., and Edward C. Prescott 1995. "Economic growth and business cycles." *Frontiers of business cycle research.*

Cordoba, Juan-Carlos, and Marla Ripoll 2004. "Credit cycles redux." *International Economic Review* 45.4: 1011-1046.

Gerali, Andrea, et al. 2010. "Credit and Banking in a DSGE Model of the Euro Area." *Journal of Money, Credit and Banking* 42.s1: 107-141.

Gomme, Paul, and Peter Rupert 2007. "Theory, measurement and calibration of macroeconomic models." *Journal of Monetary Economics* 54.2: 460-497.

Holmstrom, Bengt, and Jean Tirole 1997. "Financial intermediation, loanable funds, and the real sector." *the Quarterly Journal of economics* 112.3: 663-691.

Iacoviello, Matteo 2005. "House prices, borrowing constraints, and monetary policy in the business cycle." *American economic review* 95.3: 739-764.

Iacoviello, Matteo, and Stefano Neri 2010. "Housing market spillovers: evidence from an estimated DSGE model." *American Economic Journal: Macroeconomics* 2.2: 125-64.

Iacoviello, Matteo 2015. "Financial business cycles." *Review of Economic Dynamics* 18.1: 140-163.

Ireland, Peter N. 2004. "A method for taking models to the data." *Journal of Economic Dynamics and Control* 28.6: 1205-1226.

Ireland, Peter N. 2004. "Technology shocks in the new Keynesian model." *Review of Economics and Statistics* 86.4: 923-936.

Maynard, Keynes John. 1931. "The consequences for the banks of the collapse of money value." *Essays in Persuasion, Collected Writtings of JM Keynes* 9: 150-158.

Kiyotaki, Nobuhiro, and John Moore 1997. "Credit cycles." *Journal of political economy* 105.2: 211-248.

Kocherlakota, Narayana R. 2000. "Creating business cycles through credit constraints." *Federal Reserve Bank of Minneapolis. Quarterly Review-Federal Reserve Bank of Minneapolis* 24.3: 2.

León, Elmer Sánchez 2016. *Mortgage credit: Lending and borrowing constraints in a DSGE framework*. No. 15-2016. Graduate Institute of International and Development Studies Working Paper.

Lombardo, Giovanni, and David Vestin 2008. "Welfare implications of Calvo vs. Rotemberg-pricing assumptions." *Economics Letters* 100.2: 275-279.

Liu, Zheng, Jianjun Miao, and Tao Zha 2016. "Land prices and unemployment." *Journal of Monetary Economics* 80: 86-105.

Nistico, Salvatore 2007. "The welfare loss from unstable inflation." *Economics Letters* 96.1: 51-57.

Nivievskyi, Oleg, and Heinz Strubenhoff 2017. "Where will demand for land come from? Evidence from farm models." https://www.researchgate.net/publication/315807984.pdf

Nizalov, Denis 2017. "Land reform is not beneficial for those who work under shadow schemes." *Vox Ukraine*. https://voxukraine.org/uk/ekonomika-139-denis-nizalov-zemelna-reforma-nevigidna-tim-hto-pratsyuye-za-tinovimi-shemami/

Rotemberg, Julio J. 1982. "Sticky prices in the United States." *Journal of Political Economy* 90.6: 1187-1211.

Townsend, Robert M. 1979. "Optimal contracts and competitive markets with costly state verification." *Journal of Economic theory* 21.2: 265-293.

Uhlig, Harald F. 1995 "A toolkit for analyzing nonlinear dynamic stochastic models easily." *Computational methods for the study of dynamic economies*. Oxford: Oxford University Press: 30-61.

APPENDIX A

OPTIMIZATION PROBLEM OF PATIENT HOUSEHOLDS IN THE INITIAL MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{P^t} \left(\ln c_t^p + j_t \ln h_t^p - \frac{L_t^{P^\eta}}{\eta} \right) + \lambda_t^P (b_t^P + w_t^P L_t^P + r_t^P Z^P + F_t$$

$$+ T_t^P - c_t^P - q_t^h (h_t^P - h_{t-1}^P) - R_{t-1} \frac{b_{t-1}^P}{\pi_t})$$

Labor supply:

$$L_t^{P^{\eta-1}} = \frac{w_t^P}{c_t^P}$$

Housing demand:

$$\frac{q_t^h}{c_t^P} = \frac{j_t}{h_t^p} + \beta^P E_t \frac{q_{t+1}^h}{c_{t+1}^P}$$

Euler equation:

$$\frac{1}{c_t^P} = \beta^P E_t \frac{R_t}{c_{t+1}^P \pi_{t+1}}$$

APPENDIX B

OPTIMIZATION PROBLEM OF IMPATIENT HOUSEHOLDS IN THE INITIAL MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} {\beta^I}^t \left(\ln c_t^I + j_t \ln h_t^I - \frac{{L_t^I}^\eta}{\eta} \right) + \lambda_t^I (b_t^I + w_t^I L_t^I + r_t^I Z^I + T_t^I - c_t^I - q_t^h (h_t^I - h_{t-1}^I) - R_{t-1} \frac{b_{t-1}^I}{\pi_t}) + \mu_t^I (m_t \pi_{t+1} q_{t+1}^h h_t^I - R_t b_t^I)$$

Labor supply:

$${L_t^I}^{\eta-1} = \frac{w_t^I}{c_t^I}$$

Housing demand:

$$\frac{q_t^h}{c_t^I} = \frac{j_t}{h_t^I} + \beta^I E_t \frac{q_{t+1}^h}{c_{t+1}^I} + \left(\frac{1}{c_t^I R_t} - \beta^I E_t \frac{1}{c_{t+1}^I \pi_{t+1}} \right) E_t m_t^I \pi_{t+1} q_{t+1}^h$$

APPENDIX C

OPTIMIZATION PROBLEM OF ENTREPRENEURS IN THE INITIAL MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E$$

$$+ \lambda_t^E \left(\frac{Y_t}{X_t} + b_t^E - c_t^E - q_t^h (h_t^E - h_{t-1}^E) - R_{t-1} \frac{b_{t-1}^E}{\pi_t} - w_t^I L_t^I \right.$$

$$\left. - w_t^P L_t^P - r_t^I Z^I - r_t^P Z^P - I_t - \frac{\psi}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1} \right)$$

$$+ \mu_t^E \left(m_t \pi_{t+1} q_{t+1}^h h_t^E - R_t b_t^E \right) + u_t^E (I_t - K_t + (1-\delta) K_{t-1})$$

$$+ s_t^E (A_t K_{t-1}^{\mu} h_{E,t-1}^{v} (Z_E^{\varphi} Z_P^{d} Z_I^{1-\varphi-d})^{u} \left(L_{P,t}^{\alpha} L_{I,t}^{1-\alpha} \right)^{1-\mu-u-v} - Y_t)$$

Patient labor demand:

$$w_t^P = \frac{\alpha(1-\mu-v-u) Y_t}{X_t L_t^P}$$

Impatient labor demand:

$$w_t^I = \frac{(1-\alpha)(1-\mu-v-u) Y_t}{X_t L_t^I}$$

Investment schedule:

$$\frac{1}{c_t^E}\left(1+\frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)\right)$$

$$=E_t\left(\frac{\beta^E}{c_{t+1}^E}\frac{\mu Y_{t+1}}{X_{t+1}K_t}+(1-\delta)\frac{\beta^E}{c_{t+1}^E}\left(1+\frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)\right)\right.$$

$$\left.-\frac{1}{c_{t+1}^E}\left(\frac{\psi_K}{2\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)-\frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)\frac{I_{t+1}}{K_t}\right)\right)$$

Housing demand:

$$\frac{q_t^E}{c_t^E}=\left(\frac{\beta^E}{c_{t+1}^E}\frac{vY_{t+1}}{X_{t+1}h_t^E}+\beta^E\frac{q_{t+1}^h}{c_{t+1}^E}+\left(\frac{1}{c_t^E R_t}-\beta^E\frac{1}{c_{t+1}^E\pi_{t+1}}\right)m_t^E\pi_{t+1}q_{t+1}^h\right)$$

APPENDIX D

OPTIMIZATION PROBLEM OF PATIENT HOUSEHOLDS IN THE MODIFIED MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{P^t} \left(\ln c_t^p + j_t \ln h_t^p - \frac{L_t^{P^\eta}}{\eta} \right) + \lambda_t^E (b_t^P + w_t^P L_t^P + r_t^P Z_{t-1}^P + F_t$$

$$+ T_t^P - c_t^P - q_t^h (h_t^P - h_{t-1}^P) - q_t^Z (Z_t^P - Z_{t-1}^P) - R_{t-1} \frac{b_{t-1}^P}{\pi_t})$$

Labor supply:

$$L_t^{p^{\eta-1}} = \frac{w_t^P}{c_t^P}$$

Housing demand:

$$\frac{q_t^h}{c_t^P} = \frac{j_t}{h_t^p} + \beta^P E_t \frac{q_{t+1}^h}{c_{t+1}^P}$$

Euler equation:

$$\frac{1}{c_t^P} = \beta^P E_t \frac{R_t}{c_{t+1}^P \pi_{t+1}}$$

Land-consumption ratio:

$$\frac{q_t^Z}{c_t^P} = \beta^P E_t \left(\frac{q_{t+1}^Z + r_{t+1}^p}{c_{t+1}^P} \right)$$

APPENDIX E

OPTIMIZATION PROBLEM OF IMPATIENT HOUSEHOLDS IN THE MODIFIED MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} {\beta^I}^t \left(\ln c_t^I + j_t \ln h_t^I - \frac{{L_t^I}^\eta}{\eta} \right) + \lambda_t^I (b_t^I + w_t^I L_t^I + r_t^I Z^I + T_t^I - c_t^I$$

$$- q_t^h (h_t^I - h_{t-1}^I) - q_t^Z (Z_t^I - Z_{t-1}^I) - R_{t-1} \frac{b_{t-1}^I}{\pi_t})$$

$$+ \mu_t^I (m_t \pi_{t+1} (q_{t+1}^h h_t^I + q_{t+1}^Z Z_t^I) - R_t b_t^I)$$

Labor supply:

$${L_t^I}^{\eta-1} = \frac{w_t^I}{c_t^I}$$

Housing demand:

$$\frac{q_t^h}{c_t^I} = \frac{j_t}{h_t^I} + \beta^I E_t \frac{q_{t+1}^h}{c_{t+1}^I} + \left(\frac{1}{c_t^I R_t} - \beta^I E_t \frac{1}{c_{t+1}^I \pi_{t+1}} \right) E_t m_t \pi_{t+1} q_{t+1}^h$$

Land-consumption ratio:

$$\frac{q_t^Z}{c_t^I} = \beta^I E_t \left(\frac{q_{t+1}^Z + r_{t+1}^I}{c_{t+1}^I} \right) + \left(\frac{1}{c_t^I R_t} - \beta^I E_t \frac{1}{c_{t+1}^I \pi_{t+1}} \right) E_t m_t \pi_{t+1} q_{t+1}^Z$$

APPENDIX F

OPTIMIZATION PROBLEM OF ENTREPRENEURS IN THE MODIFIED MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E$$

$$+ \lambda_t^E \Bigg(\frac{Y_t}{X_t} + b_t^E - c_t^E - q_t^h (h_t^E - h_{t-1}^E) - q_t^Z (Z_t^E - Z_{t-1}^E)$$

$$- R_{t-1} \frac{b_{t-1}^E}{\pi_t} - w_t^I L_t^I - w_t^P L_t^P - r_t^I Z_{t-1}^I + r_t^P Z_{t-1}^P - I_t$$

$$- \frac{\psi}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1} \Bigg)$$

$$+ \mu_t^E \left(m_t \pi_{t+1} (q_{t+1}^h h_t^E + q_{t+1}^Z Z_t^E) - R_t b_t^E \right) + u_t^E (I_t - K_t$$

$$+ (1 - \delta) K_{t-1})$$

$$+ s_t^E (A_t K_{t-1}^{\mu} h_{E,t-1}^{v} (Z_{E,t-1}^{\varphi} Z_{P,t-1}^{d} Z_{I,t-1}^{1-\varphi-d})^u \left(L_{P,t}^{\alpha} L_{I,t}^{1-\alpha} \right)^{1-\mu-u-v}$$

$$- Y_t)$$

Demand for patient households' labor

$$w_t^P = \frac{\alpha(1 - \mu - v - u) Y_t}{X_t L_t^P}$$

Demand for impatient households' labor

$$w_t^I = \frac{(1 - \alpha)(1 - \mu - v - u) Y_t}{X_t L_t^I}$$

Demand for patient households' land

$$r_{t+1}^{P} = \frac{duY_{t+1}}{X_{t+1}Z_{t}^{P}}$$

Demand for impatient households' land

$$r_{t+1}^{I} = \frac{(1-\varphi-d)uY_{t+1}}{X_{t+1}Z_{t}^{I}}$$

Land-consumption relation:

$$\frac{q_t^Z}{c_t^E} = \left(\frac{\beta^E}{c_{t+1}^E}\frac{\varphi u Y_{t+1}}{X_{t+1}Z_t^E} + \beta^E\frac{q_{t+1}^Z}{c_{t+1}^E} + \left(\frac{1}{c_t^E R_t} - \beta^E\frac{1}{c_{t+1}^E \pi_{t+1}}\right)m_t\pi_{t+1}q_{t+1}^Z\right)$$

Optimal investment schedule:

$$\frac{1}{c_t^E}\left(1+\frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)\right) = E_t\left(\frac{\beta^E}{c_{t+1}^E}\frac{\mu Y_{t+1}}{X_{t+1}K_t} + (1-\delta)\frac{\beta^E}{c_{t+1}^E}\left(1+\frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\right.\right.\right.$$

$$\left.\left.\delta\right)\right) - \frac{1}{c_{t+1}^E}\left(\frac{\psi_K}{2\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right) - \frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}}-\delta\right)\frac{I_{t+1}}{K_t}\right)\Bigg)$$

Housing-consumption relation:

$$\frac{q_t^h}{c_t^E} = \left(\frac{\beta^E}{c_{t+1}^E}\frac{vY_{t+1}}{X_{t+1}h_t^E} + \beta^E\frac{q_{t+1}^h}{c_{t+1}^E} + \left(\frac{1}{c_t^E R_t} - \beta^E\frac{1}{c_{t+1}^E \pi_{t+1}}\right)m_t\pi_{t+1}q_{t+1}^h\right)$$

APPENDIX G

THE STEADY-STATE RATIOS OF THE INITIAL MODEL

$$\frac{I}{Y} = \frac{\beta^e \mu}{(1 - \beta^e - \delta\beta^e)X}\delta \stackrel{\text{def}}{=} \xi_1 \delta$$

$$\frac{q^h h^E}{Y} = \frac{\beta^E v}{X(1 - \beta^E - m\beta^P + \beta^E m)} \stackrel{\text{def}}{=} \xi_5$$

$$\frac{q^h h^P}{Y} = \frac{j}{(1 - \beta^P)}\frac{c^p}{Y} \stackrel{\text{def}}{=} \xi_6 \frac{c^p}{Y}$$

$$\frac{q^h h^I}{Y} = \frac{j}{(1 - \beta^I - m\beta^P + \beta^I m)}\frac{c^I}{Y} \stackrel{\text{def}}{=} \xi_7 \frac{c^I}{Y}$$

$$\frac{c^E}{Y} = \frac{\mu + \vartheta + \varphi u}{X} + (\beta^P - 1)m\xi_5 - \xi_1\delta$$

$$\frac{c^I}{Y} = \frac{((1 - \alpha)(1 - \mu - v - u) + (1 - \varphi - t)u)}{X(1 - (\beta^P - 1)m\xi_7)}$$

$$\frac{c^P}{Y} = 1 - \frac{c^I}{Y} - \frac{c^E}{Y} - \frac{I}{Y}$$

APPENDIX H

EQUILIBRIUM DYNAMICS FOR THE INITIAL MODEL

$$\tilde{Y}_t = \frac{c^E}{Y}\tilde{c}_t^E + \frac{c^P}{Y}\tilde{c}_t^p + \frac{c^I}{Y}\tilde{c}_t^I + \frac{I}{Y}\tilde{I}_t$$

$$\tilde{c}_{t+1}^P = \tilde{c}_t^P + \tilde{R}_t - \tilde{\pi}_{t+1}$$

$$\tilde{q}_t^h = \beta^P \tilde{q}_{t+1}^h + \tilde{c}_t^P - \beta^P \tilde{c}_{t+1}^P + (1-\beta^P)\left(\tilde{j}_t + \frac{h^E}{h^P}\tilde{h}_t^E + \frac{h^I}{h^P}\tilde{h}_t^I\right)$$

$$\tilde{q}_t^h = \gamma_h \tilde{q}_{t+1}^h + (1-\gamma_h)\left(\tilde{j}_t - \tilde{h}_t^I\right) + (1-\beta^P m)\tilde{c}_t^I + (\beta^I m - \beta^P)\tilde{c}_{t+1}^I + \beta^P m\left(\tilde{\pi}_{t+1} - \tilde{R}_t\right) + m(\beta^P - \beta^I)\tilde{m}_t$$

$$\tilde{q}_t^h = \gamma_e \tilde{q}_{t+1}^h + (1-\gamma_e)\left(\tilde{Y}_{t+1} - \tilde{X}_{t+1} - \tilde{h}_t^E\right) - (1-\beta^P m)(\tilde{c}_{t+1}^E - \tilde{c}_t^E) - \beta^P m\left(\tilde{R}_t - \tilde{\pi}_{t+1}\right) + m(\beta^E - \beta^I)\tilde{m}_t$$

$$\tilde{K}_t = (1-\delta)\tilde{K}_{t-1} + \delta\tilde{I}_t$$

$$\tilde{b}_t^E = \tilde{m}_t + \tilde{q}_{t+1}^h + \tilde{h}_t^E + \tilde{\pi}_{t+1} - \tilde{R}_t$$

$$\tilde{b}_t^I = \tilde{m}_t + \tilde{q}_{t+1}^h + \tilde{h}_t^I + \tilde{\pi}_{t+1} - \tilde{R}_t$$

$$\frac{(1-\alpha)(1-\mu-v-u) + (1-\varphi-d)u)Y}{X}\left(\tilde{Y}_t - \tilde{X}_t\right) + b^I\tilde{b}_t^I = c^I\tilde{c}_t^I + q^h h^I\left(\tilde{h}_t^I - \tilde{h}_{t-1}^I\right) + Rb^I\left(\tilde{b}_{t-1}^I - \tilde{\pi}_t + \tilde{R}_{t-1}\right)$$

$$\frac{(\mu + v + \varphi u)Y}{X}\left(\tilde{Y}_t - \tilde{X}_t\right) + b^E \tilde{b}_t^E$$

$$= c^E \tilde{c}_t^E + q^h \mathrm{h}^{\mathrm{E}}\left(\tilde{\mathrm{h}}_{\mathrm{t}}^{\mathrm{E}} - \tilde{\mathrm{h}}_{\mathrm{t-1}}^{\mathrm{E}}\right) + \mathrm{Rb}^{\mathrm{E}}\left(\tilde{b}_{t-1}^E - \tilde{\pi}_t + \tilde{R}_{t-1}\right) + I\tilde{I}_t$$

$$\tilde{Y}_t = \frac{\eta}{\eta - 1 + \mu + u + v}\left(\tilde{A}_t + \mu \tilde{K}_{t-1} + v\tilde{h}_{t-1}^E\right)$$

$$- \frac{1 - \mu - v - u}{\eta - 1 + \mu + u + v}\left(\tilde{X}_t + \alpha \tilde{c}_t^P + (1 - \alpha)\tilde{c}_t^I\right)$$

$$\tilde{\pi}_t = \beta^{\mathrm{P}} E_t \tilde{\pi}_{t+1} + \frac{(1 - \theta)(1 - \beta^{\mathrm{P}}\theta)}{\theta}\tilde{X}_t$$

$$\tilde{R}_t = r_R \tilde{R}_{t-1} + (1 - r_R)\Big((1 + r_\pi)\tilde{\pi}_{t-1} + r_Y \tilde{Y}_{t-1}\Big) + \tilde{e}_{R,t}$$

$$\tilde{\mathrm{A}}_{\mathrm{t}} = \rho_{\mathrm{A}} \tilde{\mathrm{A}}_{\mathrm{t-1}} + \tilde{\varepsilon}_{\mathrm{A,t}}$$

$$\tilde{\mathrm{j}}_{\mathrm{t}} = \rho_{\mathrm{h}} \tilde{\mathrm{j}}_{\mathrm{t-1}} + \tilde{\varepsilon}_{\mathrm{h,t}}$$

$$\tilde{\mathrm{e}}_{\mathrm{R,t}} = \rho_{\mathrm{e}} \tilde{\mathrm{e}}_{\mathrm{R,t-1}} + \tilde{\varepsilon}_{\mathrm{R,t}}$$

$$\tilde{\mathrm{m}}_{\mathrm{t}} = \rho_{\mathrm{m}} \tilde{\mathrm{m}}_{\mathrm{t-1}} + \tilde{\varepsilon}_{\mathrm{m,t}}$$

where $\gamma_h = \beta^{\mathrm{I}} + \beta^{\mathrm{P}}\mathrm{m} - \beta^{\mathrm{I}}\mathrm{m}$, $\gamma_e = \beta^{\mathrm{E}} + \beta^{\mathrm{P}}\mathrm{m} - \beta^{\mathrm{E}}\mathrm{m}$

APPENDIX I

THE STEADY-STATE RATIOS OF THE MODIFIED MODEL

$$\frac{I}{Y}=\frac{\beta^{e}\mu}{(1-\beta^{e}-\delta\beta^{e})X}\delta \stackrel{\text{def}}{=} \xi_1\delta$$

$$\frac{q^{z}Z^{P}}{Y}=\frac{du}{X(1-\beta^{P})} \stackrel{\text{def}}{=} \xi_2$$

$$\frac{q^{z}Z^{I}}{Y}=\frac{\beta^{P}(1-\varphi-d)u}{X(1-\beta^{I}-m\beta^{P}+\beta^{I}m)} \stackrel{\text{def}}{=} \xi_3$$

$$\frac{q^{z}Z^{e}}{Y}=\frac{\beta^{E}\varphi u}{X(1-\beta^{E}-m\beta^{P}+\beta^{E}m)} \stackrel{\text{def}}{=} \xi_4$$

$$\frac{q^{h}h^{E}}{Y}=\frac{\beta^{E}v}{X(1-\beta^{E}-m\beta^{P}+\beta^{E}m)} \stackrel{\text{def}}{=} \xi_5$$

$$\frac{q^{h}h^{P}}{Y}=\frac{j}{(1-\beta^{P})}\frac{c^{p}}{Y} \stackrel{\text{def}}{=} \xi_6\frac{c^{p}}{Y}$$

$$\frac{q^{h}h^{I}}{Y}=\frac{j}{(1-\beta^{I}-m\beta^{P}+\beta^{I}m)}\frac{c^{I}}{Y} \stackrel{\text{def}}{=} \xi_7\frac{c^{I}}{Y}$$

$$\frac{c^E}{Y} = \frac{\mu + \vartheta + \varphi u}{X} + (\beta^P - 1)m(\xi_4 + \xi_5) - \xi_1\delta$$

$$\frac{c^I}{Y} = \frac{((1-\alpha)(1-\mu-v-u) + (1-\varphi-t)u) + X(\beta^P - 1)m\xi_3}{X(1-(\beta^P - 1)m\xi_7)}$$

$$\frac{c^P}{Y} = 1 - \frac{c^I}{Y} - \frac{c^E}{Y} - \frac{I}{Y}$$

APPENDIX J

EQUILIBRIUM DYNAMICS FOR THE MODIFIED MODEL

$$\widetilde{Y}_t = \frac{c^E}{Y}\tilde{c}_t^E + \frac{c^P}{Y}\tilde{c}_t^p + \frac{c^I}{Y}\tilde{c}_t^I + \frac{I}{Y}\tilde{I}_t$$

$$\tilde{c}_{t+1}^P = \tilde{c}_t^P + \widetilde{R}_t - \widetilde{\pi}_{t+1}$$

$$\tilde{q}_t^h = \beta^P \tilde{q}_{t+1}^h + \tilde{c}_t^P - \beta^P \tilde{c}_{t+1}^P + (1-\beta^P)\left(\tilde{j}_t + \frac{h^E}{h^P}\widetilde{h}_t^E + \frac{h^I}{h^P}\widetilde{h}_t^I\right)$$

$$\tilde{q}_t^Z = \beta^P \tilde{q}_{t+1}^Z + \tilde{c}_t^P - \beta^P \tilde{c}_{t+1}^P + (1-\beta^P)\left(\widetilde{Y}_{t+1} - \widetilde{X}_{t+1} + \frac{Z^E}{Z^P}\tilde{Z}_t^E + \frac{Z^I}{Z^P}\tilde{Z}_t^I\right)$$

$$\tilde{q}_t^h = \gamma_h \tilde{q}_{t+1}^h + (1-\gamma_h)\left(\tilde{j}_t - \widetilde{h}_t^I\right) + (1-\beta^P m)\tilde{c}_t^I + (\beta^I m - \beta^P)\tilde{c}_{t+1}^I$$
$$+ \beta^P m\left(\widetilde{\pi}_{t+1} - \widetilde{R}_t\right) + m(\beta^P - \beta^I)\widetilde{m}_t$$

$$\tilde{q}_t^Z = \gamma_h \tilde{q}_{t+1}^Z + (1-\gamma_h)\left(\widetilde{Y}_{t+1} - \widetilde{X}_{t+1} - \tilde{Z}_t^I\right) + (1-\beta^P m)\tilde{c}_t^I$$
$$+ (\beta^I m - \beta^P)\tilde{c}_{t+1}^I + \beta^P m\left(\widetilde{\pi}_{t+1} - \widetilde{R}_t\right) + m(\beta^P - \beta^I)\widetilde{m}_t$$

$$\tilde{q}_t^h = \gamma_e \tilde{q}_{t+1}^h + (1-\gamma_e)\left(\widetilde{Y}_{t+1} - \widetilde{X}_{t+1} - \widetilde{h}_t^E\right) - (1-\beta^P m)(\tilde{c}_{t+1}^E - \tilde{c}_t^E)$$
$$- \beta^P m\left(\widetilde{R}_t - \widetilde{\pi}_{t+1}\right) + m(\beta^E - \beta^I)\widetilde{m}_t$$

$$\widetilde{K}_t = (1-\delta)\widetilde{K}_{t-1} + \delta\tilde{I}_t$$

$$Rb^E\left(\tilde{b}_t^E + \tilde{R}_t\right) = mq^h h^E\left(\tilde{m}_t + \tilde{q}_{t+1}^h + \tilde{h}_t^E + \tilde{\pi}_{t+1}\right) + mq^Z Z^E(\tilde{m}_t + \tilde{q}_{t+1}^Z + \tilde{Z}_t^E + \tilde{\pi}_{t+1})$$

$$Rb^I\left(\tilde{b}_t^I + \tilde{R}_t\right) = mq^h h^I\left(\tilde{m}_t + \tilde{q}_{t+1}^h + \tilde{h}_t^I + \tilde{\pi}_{t+1}\right) + mq^Z Z^I(\tilde{m}_t + \tilde{q}_{t+1}^Z + \tilde{Z}_t^I + \tilde{\pi}_{t+1})$$

$$\frac{(1-\alpha)(1-\mu-v-u)+(1-\varphi-d)u)Y}{X}\left(\tilde{Y}_t - \tilde{X}_t\right) + b^I\tilde{b}_t^I = c^I\tilde{c}_t^I + q^h h^I\left(\tilde{h}_t^I - \tilde{h}_{t-1}^I\right) + Rb^I\left(\tilde{b}_{t-1}^I - \tilde{\pi}_t + \tilde{R}_{t-1}\right) + q^Z Z^I\left(\tilde{Z}_t^I - \tilde{Z}_{t-1}^I\right)$$

$$\frac{(\mu+v+\varphi u)Y}{X}\left(\tilde{Y}_t - \tilde{X}_t\right) + b^E\tilde{b}_t^E = c^E\tilde{c}_t^E + q^h h^E\left(\tilde{h}_t^E - \tilde{h}_{t-1}^E\right) + Rb^E\left(\tilde{b}_{t-1}^E - \tilde{\pi}_t + \tilde{R}_{t-1}\right) + I\tilde{I}_t + q^Z Z^E\left(\tilde{Z}_t^E - \tilde{Z}_{t-1}^E\right)$$

$$\tilde{Y}_t = \frac{\eta}{\eta-1+\mu+u+v}\left(\tilde{A}_t + \mu\tilde{K}_{t-1} + v\tilde{h}_{t-1}^E\right) - \frac{1-\mu-v-u}{\eta-1+\mu+u+v}\left(\tilde{X}_t + \alpha\tilde{c}_t^P + (1-\alpha)\tilde{c}_t^I\right)$$

$$\tilde{\pi}_t = \beta^P E_t\tilde{\pi}_{t+1} + \frac{(1-\theta)(1-\beta^P\theta)}{\theta}\tilde{X}_t$$

$$\tilde{R}_t = r_R\tilde{R}_{t-1} + (1-r_R)\left((1+r_\pi)\tilde{\pi}_{t-1} + r_Y\tilde{Y}_{t-1}\right) + \tilde{e}_{R,t}$$

$$\tilde{A}_t = \rho_A\tilde{A}_{t-1} + \tilde{\varepsilon}_{A,t}$$

$$\tilde{J}_t = \rho_h \tilde{J}_{t-1} + \tilde{\varepsilon}_{h,t}$$

$$\tilde{e}_{R,t} = \rho_e \tilde{e}_{R,t-1} + \tilde{\varepsilon}_{R,t}$$

$$\widetilde{m}_t = \rho_m \widetilde{m}_{t-1} + \tilde{\varepsilon}_{m,t}$$

APPENDIX K

TAYLOR RULE ESTIMATION

Table 3. Results of the Taylor rule estimation

	Dependent variable:
	interest
Output	-0.008
	(0.074)
Interest (lagged)	0.856***
	(0.134)
Inflation	0.538***
	(0.111)
Constant	2.041
	(20.568)
Observations	17
R2	0.908
Adjusted R2	0.887
Residual Std. Error	2.166 (df = 13)
F Statistic	42.934*** (df = 3; 13)
Note:	*p<0.1; **p<0.05; ***p<0.01

APPENDIX L

CALIBRATION

Table 4. Calibrated parameters

Description	Parameter	Value
Patient household discount factor	β^p	0.995
Impatient household discount factor	β^i	0.98
Entrepreneur discount factor	β^e	0.94
Housing service utility weight	j	0.05
Frisch labor supply elasticity	η	2
Capital share	μ	0.25
Land share	u	0.03
Housing share	v	0.02
Capital depreciation	δ	0.03
Steady-state LTV ratio	m	0.31
Steady-state markup	X	1.1
Patient household wage share	α	0.64
Patient households' rent share	d	0.07

Table 4 - Continued

Entrepreneurs' rent share	φ	0.84
The Taylor rule parameter of inflation response	r_π	0.54
The Taylor rule inertia parameter	r_R	0.86
The Taylor rule parameter of output response	r_Y	0.0

APPENDIX M

RECALIBRATED PARAMETERS FOR THE MODIFIED MODEL

Table 5. Recalibrated parameters

Patient households' rent share	d	0.07
Entrepreneurs' rent share	φ	0.84

APPENDIX N

ESTIMATION

Table 6. Estimation results

Description	Parameter	Value	s.e.
Persistent of the technological shock	ρ_a	0.7719	0.1839
Persistent of the monetary shock	ρ_e	0.1447	0.0367
Persistent of the loan-to-value shock	ρ_m	0.9477	0.0262
Persistent of the housing preference shock	ρ_j	0.9801	0.0092
Standard deviation of the technological shock	σ_a	0.0262	0.0035
Standard deviation of the monetary shock	σ_e	0.0089	0.0038
Standard deviation of the loan-to-value shock	σ_m	2.0002	0.3738
Standard deviation of the housing preference shock	σ_j	0.4247	0.1250
Capital adjustment costs	ψ	0.6250	0.1403
Price stickiness parameter	θ	0.3431	0.0822

APPENDIX O

ASSET PRICE FLUCTUATIONS

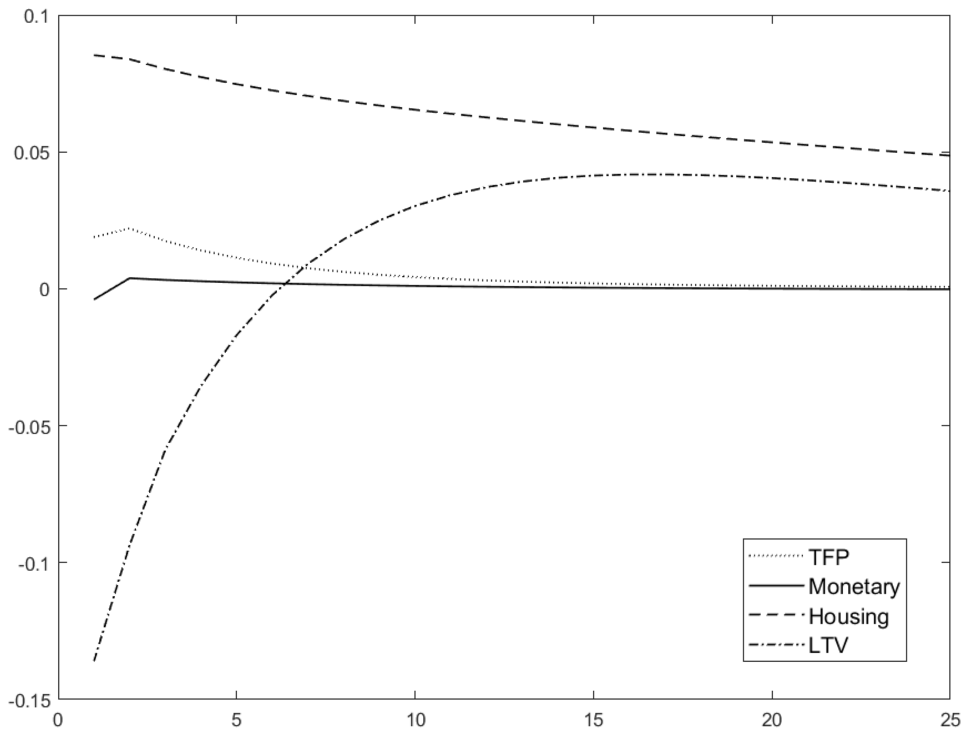

Figure 5. Asset price fluctuations caused by one standard deviation of the corresponding shock

APPENDIX P

SMOOTHED SHOCKS

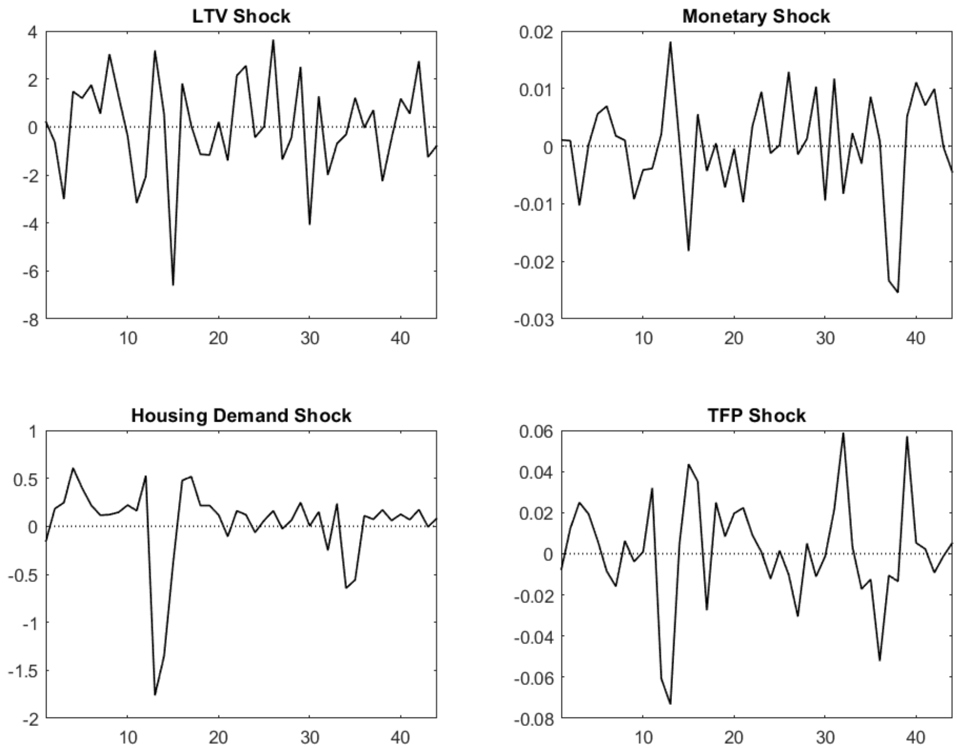

Figure 6. Smoothed shocks

APPENDIX Q

IMPULSE RESPONSE FUNCTIONS

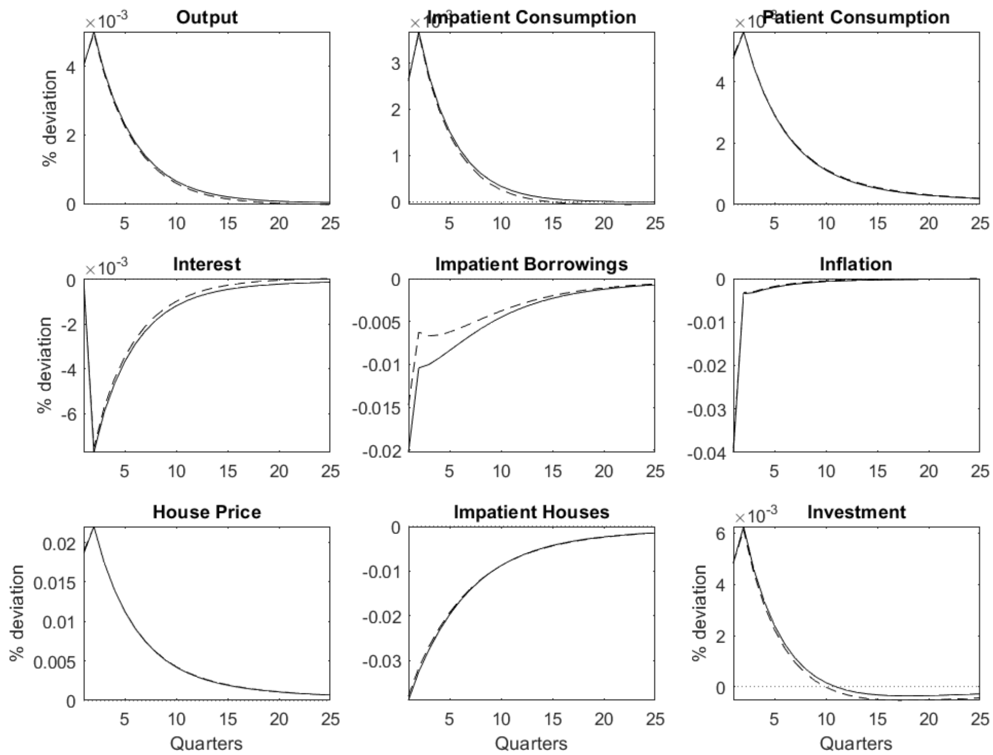

Figure 7. IRFs to TFP shock of the Initial (solid) and Modified (dashed) models

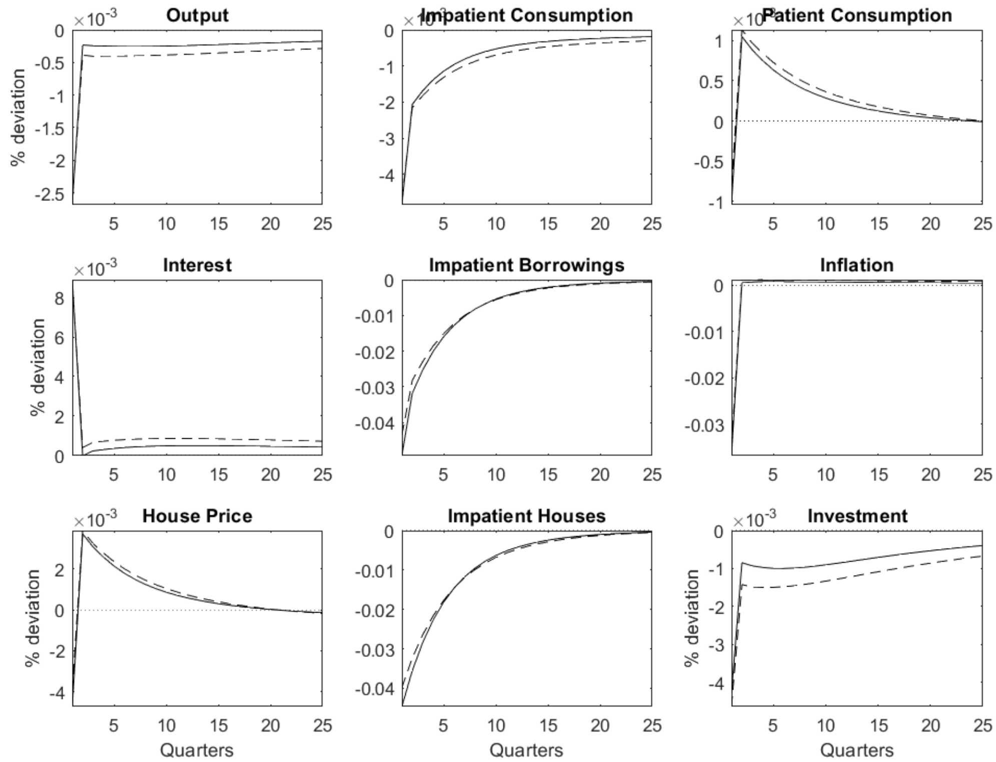

Figure 8. IRFs to monetary shock of the Initial (solid) and Modified (dashed) models

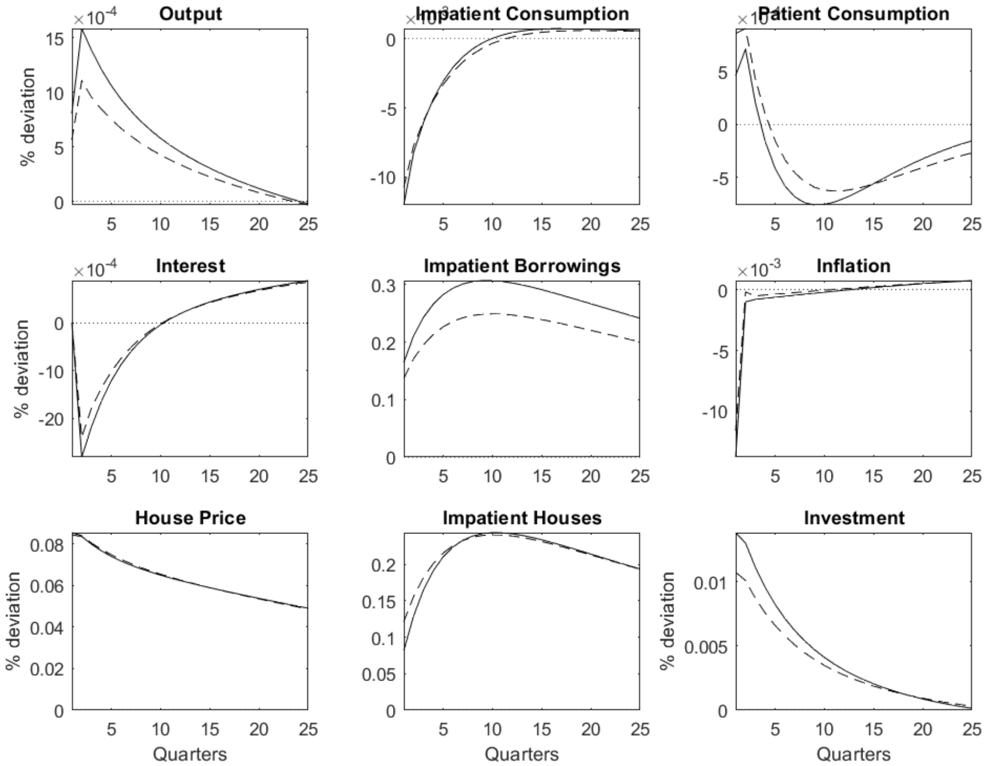

Figure 9. IRFs to house preference shock of the Initial (solid) and Modified (dashed) models

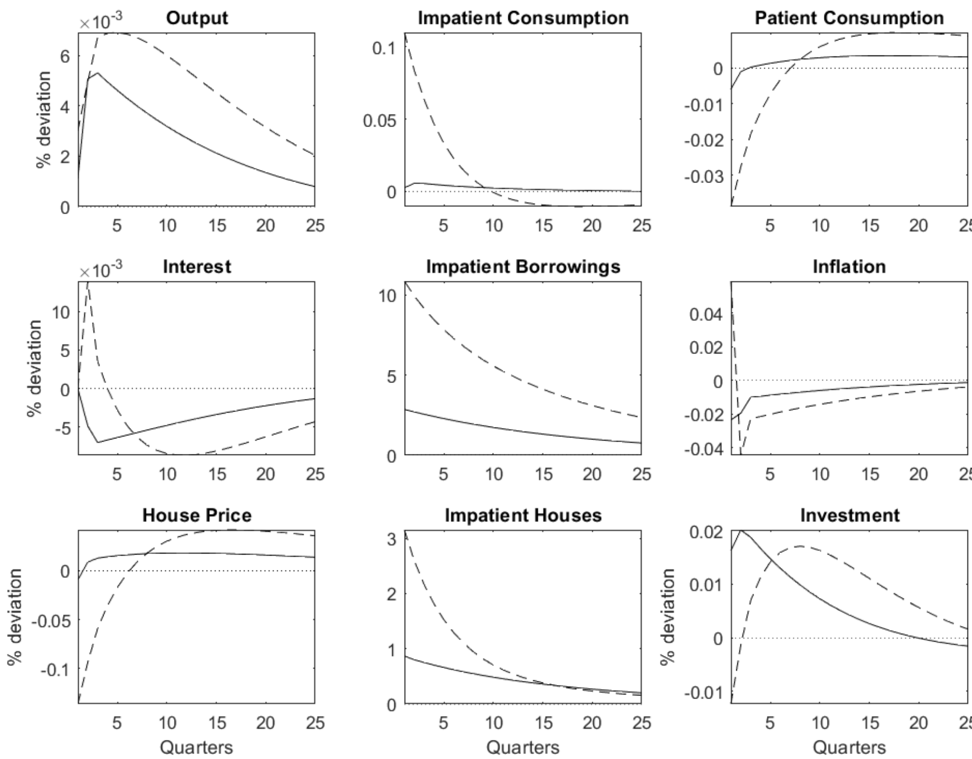

Figure 10. IRFs to LTV shock of the Initial (solid) and Modified (dashed) models