Visnyk of the National Bank of Ukraine, No. 245, 2018, pp. 4–29

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

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

JEL Codes E31, E32, E44, Q15, R21

Keywords credit cycles, land reform, collateral constraints, financial accelerator

1. INTRODUCTION

It has been almost two decades since land reform was launched in Ukraine, and the issue has prompted what seems like interminable debate on the issue. By 2001, as a result of the ongoing reform, a substantial part of the country's farmland had been distributed among the employees of the agricultural sector. However, in 2002 a moratorium on the sale of agricultural land was imposed by parliament, which suspended the functioning of the land market for more than 15 years. Along with the trade in agricultural land, the moratorium temporarily prohibits the use of agricultural land as collateral.

A new stage of the land reform debate was launched with the prolongation of the moratorium in 2017. The rights to land ownership cannot now be transferred until 2019. While the consequences of lifting the moratorium have been analyzed at the macro and micro levels, as well as from an institutional point of view, this paper investigates how macroeconomic shocks will affect business cycle dynamics under the proposed changes. Considering that the financial sector is one of the key drivers of output fluctuations during the business cycle, land collateralization could potentially facilitate access to the financial markets, and thereby influence the propagation of shocks.

To track the effect of the land reform on shock transmission and amplification in an economy with collateral constraints, I selected DSGE modelling. On the one hand, Dynamic Stochastic General Equilibrium models are microfounded, and appear to be less subject to the Lucas critique. On the other hand, the development of macroeconomic theory has drawn substantial attention to the financial accelerator, which is reflected in DSGE models. As imperfection on the financial markets may cause a quantitatively significant amplification of shocks, financial frictions were incorporated into the general equilibrium setup by Bernanke (1999) in the form of the external finance premium, and by Kiyotaki and Moore (1997), through collateral constraints. The latter approach was further developed by Iacoviello (2005), who studied collateral constraints within the New-Keynesian framework, and extended for debt deflation. Gerali et al. (2010) introduced monopolistic competition in banking sector, while Iacoviello and Neri (2010) added supply side on the housing market to capture credit cycle dynamics more accurately. Thus, structural macroeconomic models now have sufficient tools to investigate possible changes in amplification caused by collateral constraints. However, the question of the very presence of the financial accelerator in emerging economy naturally arises.

To substantiate the impact of financial imperfections on the business cycle, I partially replicated the VAR evidence of Iacoviello (2005), (Figure 1 "VAR Evidence, United States", p. 741) for Ukraine data.[1]

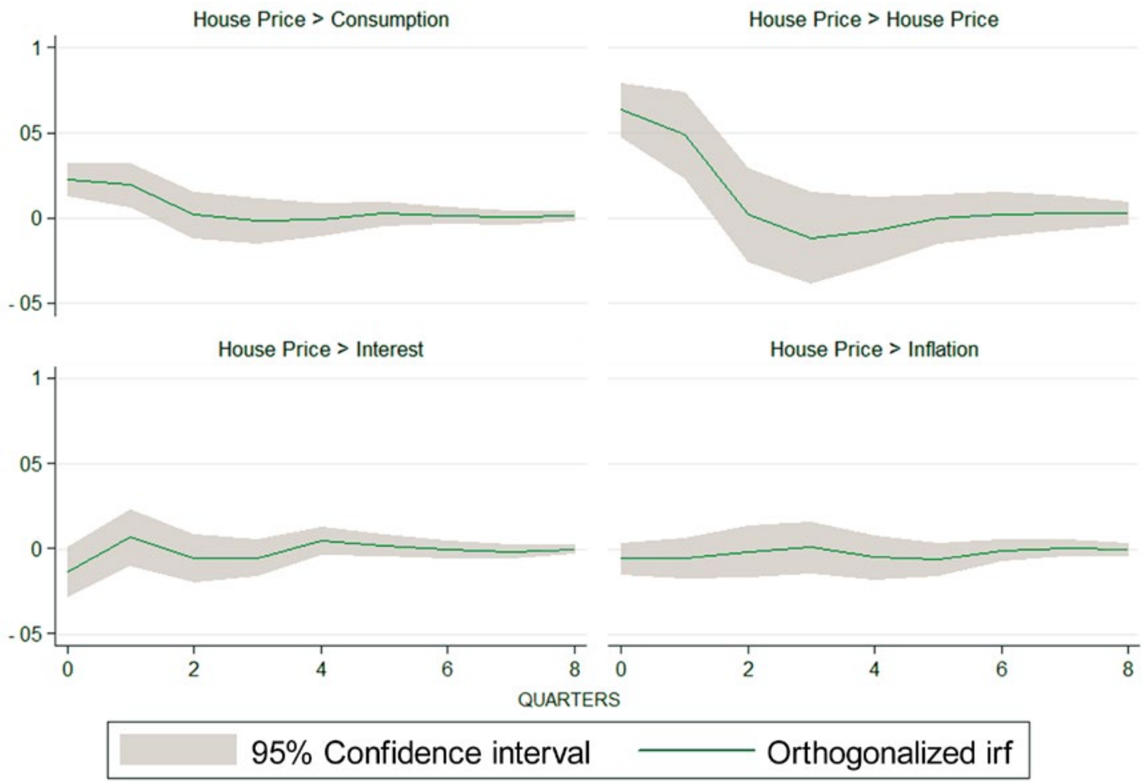
Figure 1 represents the comovement of consumption and house prices in Ukraine. This relation can be explained by the collateral effect. The mechanism is rather straightforward: in an economy with borrowing constraints, a positive shock on asset price leads to the relaxation of constraints, allowing higher consumption spending. Houses usually serve as a means of collateral, which reveals a positive correlation between their prices and consumption. Thus, VAR evidence suggests that the collateral effect may play some role in the process of shock propagation and amplification in

* A part of this paper was drafted within the framework of Research Internship Program of the National Bank of Ukraine, where the author participated. The author is grateful to (in alphabetic order) Oleksandr Faryna, Oleg Nivievskyi, and Maksym Obrizan for their useful comments and suggestions.

[1] I used 2006Q1-2016Q4 time series on private consumption spending (seasonally adjusted, $; data source: State Statistics Service of Ukraine, own calculations), interest rate (interest rates on interbank deposits 1-3 months; data source: National Bank of Ukraine), consumer price index (data source: State Statistics Service of Ukraine) and real estate price ($ per m^2, Kyiv, residential real estate, secondary market).

  https://doi.org/10.26531/vnbu2018.245.01

Figure 1. IRF to the House Price Shock



Ukraine. Consequently, the cancelation of the moratorium, which entails an increase in the amount of collateral, will affect the dynamics of the business cycle.

To simulate the changes caused by transformations on the land market, 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 tested their properties with an 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 the features of the framework elaborated by Iacoviello (2005) and further developed by Gerali et al. (2010), Iacoviello and Neri (2010). It is the Dynamic Stochastic General Equilibrium Model with monopolistic competition at the retail level, and collateral constraints taken from Kiyotaki and Moore (1997). Borrowings of economic agents must be secured by the value of houses in possession in the "initial" model, and by the value of houses or land in the "modified" one. Using land as a collateral eases the borrowing constraint, thereby altering business cycle dynamics via the financial accelerator.

In other respect, the frameworks differ in terms of the possibility to buy and sell land. The model that simulates the economy after the end of the agricultural reform enables land to be sold, while the initial model does not. In this fashion, the current paper attempts to take into account changes in the transmission mechanism in the economy of Ukraine that will take place in the near future.

The model of the actual economy was calibrated and estimated with the Maximum Likelihood procedure based on Ukrainian data. In order examine if allowing agricultural land to serve as a mean of collateral affects shock propagation, the dynamics of the factual and counterfactual economies were juxtaposed and compared by means of an IRF analysis.

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

2. AGRICULTURAL LAND IN UKRAINE

The fall of the Soviet Union accompanied by the gaining of independence brought Ukraine onto the path of liberal transformations. One example of such transformations is land reform, which was launched in March 1991. The Law on Forms of Land Ownership (1992) abolished more than 75 years of state monopoly on the right to own land, and the Land Code (1992) stipulated how land was to be transferred from state to private or collective ownership. The transfer of land to collective ownership was a transitional stage on the way to full privatization, allowing the transformation to proceed gradually.

The next stage of the reform was related to the Decree on the Order of Land Division (1995), which stipulated the procedure for the transition from collective to private ownership of land. As a result, by the end of the last century, collective farms were reorganized and about 28 million hectares of agricultural land were 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 sufficient for individual farming, which potentially created the threat that land would accumulate in the hands of big enterprises. To avoid the unfavorable consequences of market formation, a moratorium on the sale of land shares was introduced by Ukraine's parliament, the Verkhovna Rada, as a temporary measure (for four years) in 2001. The law prohibits any transfer of ownership of "pays", other than through inheritance, including land sales and land donation. The moratorium has been prolonged nine times, and currently expires on 1 January 2019. The moratorium does not permit any legal ways for farmland expropriation, so land cannot be used as collateral. At the moment, the loan-to-value ratio for agricultural land in Ukraine is zero.

Farmland constitutes 42.7 million hectares or 70.8% of the territory of Ukraine (StateGeoCadastre). 41 million hectares out of this 42.7 million hectares (that is 96%) are under the moratorium and cannot be traded. The large chunk of this land is in private ownership (30.8 million hectares), while farmland that hasn't been privatized constitutes 10.7 million hectares (in accordance with the monthly land review of StateGeoCadastre). Large agricultural enterprises hold about 6 million hectares of farmland combined (Nizalov, 2017), while the rest of the privatized land is distributed across the population.

Without taking into account shadow schemes for transferring property rights, the only way non-farmers can use land that is under the moratorium 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 in place, covering 19 million hectares of land (both state and collective). The average rental price is about $50 per hectare for private farmland, and about $107 for state land (according to StateGeoCadastre data).

Lifting the moratorium will allow to farmland to be purchased and make it possible to use land as collateral. According to the most conservative estimates, the liberalization of the land market will increase the price of agricultural land at least by 3.5 times and rental prices accordingly; land collateralization will facilitate the access to financing, and increase lending by $25 billion overall (Nizalov, 2017).

3. LITERATURE REVIEW

Irving Fisher is generally considered to have had the closest early approximation to the modern view on the financial sector. His contemplation of the roots of the Great Depression resulted in debt deflation theory, which maintains that recessions emanate from deflation, which, in turn, leads to an increase in the real value of debt. The starting point of Fisher's reasoning (1933) is an assumption of the existence of a state of over-indebtedness. On this basis, he successively deduced the sequence of developments that inevitably lead an economy into a recession after the bursting of a debt bubble. Debt liquidation, followed by a decrease in the money velocity proceeds to a price level decline, compounded by a fall in the value of businesses, resulting in falling output, unemployment, and other attributes of recession. These inferences, derived within the confines of general equilibrium theory, constitute Fisher's standpoint on the causes of the Great Depression and make him relevant to the contemporary view on the financial sector.

In a similar manner, John Maynard Keynes attached importance to the financial markets. Five years before his General Theory was published, the economic crisis in Germany became the object of Keynes' (1931) close attention, and he found the origins of its propagation to have been in the banking sector. Recession is inevitably accompanied by a fall in prices of all types of assets, including real estate. Banks, playing the role of intermediators between lenders and borrowers, may face problems meeting their obligations as a consequence of an asset price decline, which is a threat for the whole financial system. Keynes' position on the role of the fall of asset values in amplifying a downturn amplification to a great extent anticipates the views of more recent economists regarding the financial sector.

The development of the idea of the financial accelerator over the following 60 years was observed only in partial equilibrium models. A new stage of the evolution of the concept of financial frictions is usually associated with works of Bernanke. Bernanke and Gertler's (1990) OLG neoclassical model is often viewed as first attempt to construct a general equilibrium model with the financial sector. The model is used to study output fluctuations caused by changes in the credit worthiness of firms and households. The integration of financial frictions in the form of the external finance premium into the general equilibrium setup is an attempt to make the theoretical framework relevant and coherent with the observable results of monetary regulations. This necessity was induced by numerous empirical papers that were seeking an explanation for the "black box" effect of monetary policy. An example of such a work is Bernanke and Gertler (1995), who tried to rationalize the output response to monetary shock through bank lending and balance sheet channels.

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

The external finance premium could be described as "price" financial friction, as 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" types of financial frictions, incarnated in the borrowing constraint. In such models, the size of a loan available to an 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, are determined to have a fixed supply and serve at the same time as a factor of production and as a means to secure a loan. Some negative shock causes the net worth of firms to fall, which, in turn, decreases the demand for land and drives its price down. The land price drop amplifies the fall of the net worth of firms and, in this manner, the effect of the negative shock propagates. The work of Kiyotaki and Moore originated a line of DSGE models in which this transmission mechanism is inherent.

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

While the latter researchers made an attempt to study the effect of the monetary and real shocks in an economy with collateral constraints, through introduction of the price and labor frictions, Cordoba and Ripoll (2004) presented an ingenious alternative. Their model exploits the Kiyotaki-Moore economy, where heterogeneous agents have to hold enough money for transactions one period before the transaction takes place. This cash-in-advance constraint, compounded by the collateral type of borrowing constraint, generates a powerful source of shock propagation. Cordoba and Ripoll's model allows monetary shock through money injection via open market operations, and they found that the framework spawns persistent output fluctuations as result of this shock. The degree and duration of the fluctuations depend on the extent to which credit market imperfections tend to amplify initial the output increase/decline.

Iacoviello (2005) continues the tradition of Kiyotaki and Moore in many respects, and introduces several features that make this framework a "workhorse" DSGE model for these types of financial frictions. Heterogeneity among consumers and borrowers, along with nominal debt assumption as incorporated in the New-Keynesian setup allows consumption-asset price comovement (houses considered as collateral) to be captured, and brings the 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.

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

Gerali et al. (2010) further developed the DSGE with borrowing constrains model by introducing monopolistic competition in the banking sector. The model is estimated for the Euro zone, and shows that much of the fluctuation during the 2008 crisis can be explained by shocks in the banking sector. The other implication is that an imperfect banking sector has various effects on the magnitude of fluctuations caused by monetary and technological shocks.

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

In papers that focus on borrowing restrictions, there is usually only one asset under consideration. Studying the case of more than one mean of collateral can be regarded as a side stream of research. However, the question of an instant collateral increase, compounded by the issue of mutual collateral price dynamics during the business cycle, is a topic of some scientific curiosity and has some originality.

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 but identical in other respects – they draw utility from consumption and housing, and disutility from work. Patient households lend money to impatient households and entrepreneurs. An 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, labor (supplied by both types of households), land and houses. Firms sell their goods to retailers on a competitive market and buy labor on a perfect market as well.

In the models, retail firms are run by patient households. 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 housing supplies are fixed.

4.1. Initial Model

There are two principle differences between initial and modified models: (1) the presence of a free land market; (2) the possibility of using 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 is 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 the 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 repayments. These can be finances from borrowing, labor income, rent from land, profits (as patient households run retail firms that operate on a market with monopolistic competition) and lump-sum net budget transfers. In the flow of funds, all variables are specified in real terms:

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

where q^h – the real price of a 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 – the nominal interest rate, b^P – borrowings, and π – inflation.

The difference from Iacoviello (2005) is the presence of rent payments in the budget constraint. Households hold some agricultural land and can do nothing else (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 is not a subject of optimization. Thus, patient consumers choose consumption, number of working hours, housing stock and borrowing.

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

4.1.2. Impatient Households

Impatient households have a lower value for the discount factor (compared to patient ones), which 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):

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

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

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

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

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

$$R_t b_t^I \leq m_t \pi_{t+1} q_{t+1}^h h_t^I, \quad (6)$$

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

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

To make the model clearer, is also useful to draw a 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 it as collateral. Land, on the contrary, is not in the utility function, can be leased (and bring rent payments), but cannot be traded or collateralized. However, the latter two assumptions will be relaxed in the succeeding sections.

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

4.1.3. Entrepreneurs

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

$$U^E = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E. \quad (8)$$

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

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

The production function is constructed in the spirit of Iacoviello in a way that leads to analytical solutions. Output is produced 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 households. μ stands for capital share in output, v for house share in output, and 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 an AR(1) process:

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

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

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

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

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

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

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

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

$$R_t b_t^E \le m_t \pi_{t+1} q_{t+1}^h h_t^E, \quad (14)$$

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

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

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

4.1.4. Other Agents

Retailers and the central bank constitute the rest of the model, and exactly match the corresponding section in Iacoviello (2005). There is a continuum of retailers i of mass 1 that buy intermediate homogeneous goods Y for price P^W, differentiate them without cost, and sell them in an 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 the probability of price resetting equal to 1-θ, each firm maximizes discounted expected profits with respect to optimal price P*:

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

Optimization of (16) coupled with the 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:

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

where $e_{R,t}$ is a monetary policy shock, that follows the AR(1) process:

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

4.1.5. Equilibrium

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

The model describes a 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. Equilibrium on the goods market is described by equation (19).

$$Y_t = c_t^P + c_t^I + c_t^E + I_t. \quad (19)$$

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

$$L_t^{Demand} = L_t^{Supply}. \quad (20)$$

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

$$b_t^P + b_t^I + b_t^E = 0. \quad (21)$$

Supply on the housing market is fixed and does not depreciate.

$$h_t^P + h_t^I + h_t^E = \bar{H}. \quad (22)$$

4.2. Modified Model

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

4.2.1. Patient Households

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

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

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

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

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

where q_z^t 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 can be combined into four equations. They are labor supply, the housing-consumption ratio (housing demand), the Euler equation, and land supply (Appendix D). The first three exactly replicate the results of the initial model. The fourth stands for the land-consumption ratio, and arises due to the 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):

$$c_t^I + q_t^h(h_t^I - h_{t-1}^I) + q_t^Z(Z_t^I - Z_{t-1}^I) + + R_{t-1}\frac{b_{t-1}^I}{\pi_t} \leq b_t^I + w_t^I L_t^I + +r_t^I Z_{t-1}^I + T_t^I. \quad (27)$$

Borrowing constraint constitutes 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 means of collateral.

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

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

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

4.2.3. Entrepreneurs

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

$$U^E = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E. \quad (30)$$

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

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

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

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

$$c_t^E + q_t^h(h_t^E - h_{t-1}^E) + q_t^Z(Z_t^E - Z_{t-1}^E) + R_{t-1}\frac{b_{t-1}^E}{\pi_t} + + w_t^I L_t^I + w_t^P L_t^P + +r_t^I Z_{t-1}^I + r_t^P Z_{t-1}^P + I_t + \xi_t^K \leq \frac{Y_t}{X_t} + b_t^E. \quad (33)$$

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

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

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

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

4.2.4. Other Agents and Equilibrium

The rest of the model was kept unchanged. Calvo pricing at the retail level implies a Philips curve analogous to the previous one. 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 a fixed land supply, so I introduce an additional condition:

$$Z_t^P + Z_t^I + Z_t^E = \bar{Z}. \quad (36)$$

5. PARAMETERIZATION

The initial model includes 22 endogenous variables, 23 parameters and four 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 five 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. In this fashion, the initial model was log-linearized around a growthless steady-state with zero inflation, and reduced to the thirteen equations that describe the dynamics of the thirteen endogenous variables, and four equations with exogenous dynamics. The steady-states for the initial model can 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.

In the process of calibration, I was largely guided by the works of Cooley and Prescott (1995), and Gomme and Rupert (2007), who describe several approaches for parameter choice. Under the assumption of perfect competition on the input markets, input owners earn marginal products of corresponding factors of production. The most straightforward way to obtain the sought-for output shares relies on GDP data. Based on the Ukrainian GDP by income statistics for 2016 provided by the State Statistics Service of Ukraine (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 hectare, and assuming 20 million hectres of farmland in formal production, I picked $\mathfrak{u}$=0.03, so capital and housing shares have 0.27 combined. I chose a housing share equal to 0.02 in accordance with Iacoviello (2005), leaving 0.25 to capital share. The depreciation rate is determined as the 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 Grui, Lepushynskyi, Nikolaychuk (2018), the equilibrium interest rate for Ukraine is 2.5%, so I picked the discount factor for patient households as the reciprocal of the rate, which for quarterly data, is 0.995. Papers by 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 0.94 for impatient households. 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 take the results from Iacoviello (2010) and assign 64% of all labor income to patient households. The share of land rental payments received by entrepreneurs constitutes 84% of all rental payments, so φ and $\mathfrak{d}$ are 0.84 and 0.07 correspondently.

The procedure of the Taylor rule parameter calibration involves the regression of the interest rate on detrended output, inflation, and the lagged value of the interest rate. In the Ukrainian reality, the results obtained from such procedure could be rather questionable, as a valid estimation of the Taylor rule parameters can be conducted only within the data from the last few years. The results I obtained are in Table 1. The full results of the estimation can be found in in Table K1 (Appendix K). All the calibrated parameters are presented in Table K2 (Appendix K).

In estimations of the parameters of shock persistence, shock standard deviations, adjustment costs, and 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, a likelihood function of the observed data can be built according to Bauer, Haltom, and Rubio-Ramírez (2003).

As the model includes four exogenous processes, 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 for housing, and inflation. All the time series are used in the form of percentage deviations from the long-run steady-state.

The estimation results suggest high persistence of the financial and housing preferences shocks (all between 0.947and 0.980), and persistence of moderate magnitude of the technological shock. The estimates of σ_a = 0.0262 and σ_e = 0.0089 are significant, and are, as expected, 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 equal to 0.34 implies that firms on average firms reset prices each 1/(1-0.34)=1.5 quarters, which is somewhat in contrast with the standard 4 quarters. The results of the ML estimation can be found in Table K3 (Appendix K).

6. RESULTS

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

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 on the basis of steady-state ratios. I chose the discount factor of entrepreneurs to match the investment-to-output ratio. According to both NBU and UKRSTAT data, investments constitute 14-15% of GDP, so the value of β^e should be 0.94 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 to be equal to 0.31. Iacoviello (2005) assumes that the ratio is equal to 0.89, but he suggests only commercial estate as collateral. The estimates of Christensen (2007) and Gerali et al. (2010) 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 at 0.05.

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 Investment-to-Output ratio is immutable across the models (as neither land nor land parameters are included in the equation that define the ratio) and equals 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.

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

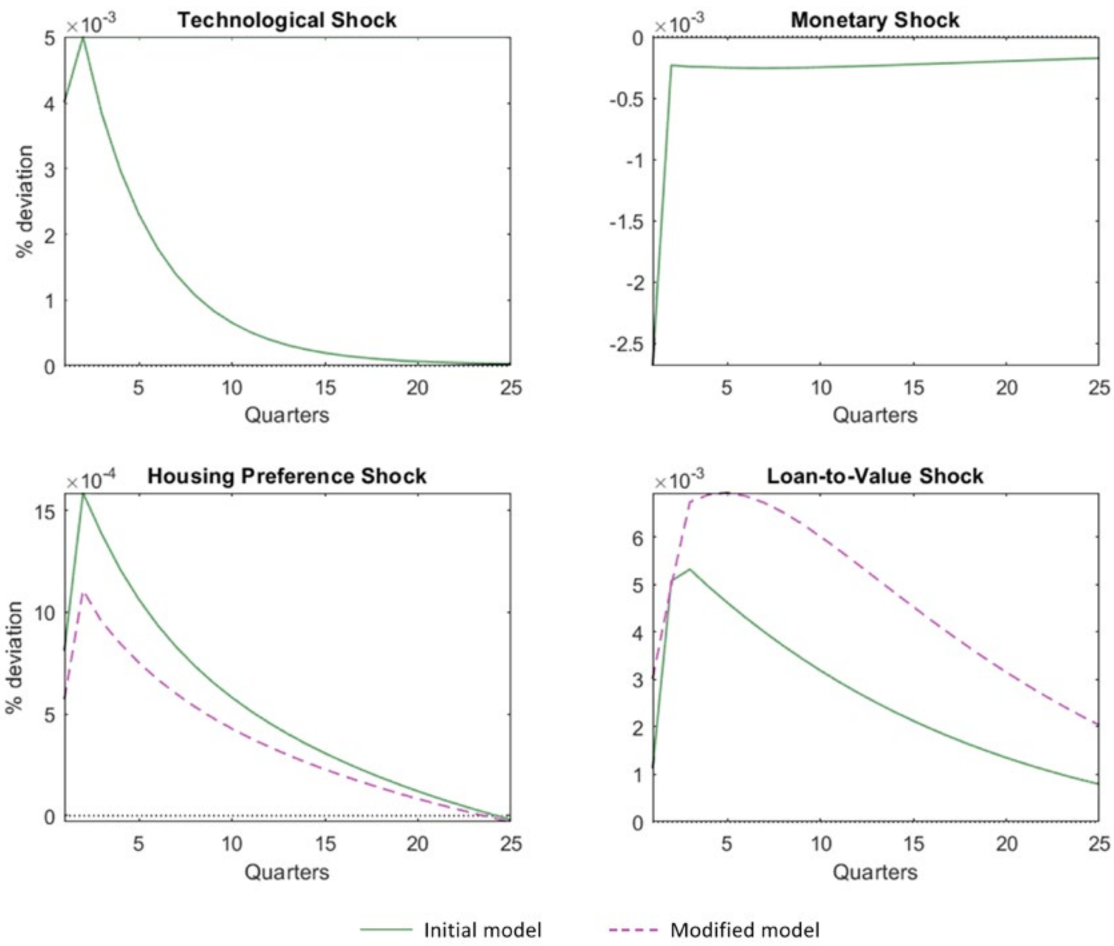
In a New-Keynesian DSGE with collateral constraints, a productivity shock may result in a counterintuitive impulse response function. Typically, a positive technological shock leads to inflation waning, through a drop in the marginal costs of production. A decrease in the inflation level fosters an enlargement in the real burden of liabilities as a result of debt deflation. Here, financial friction comes into play. The increase in the real value of debt decreases the borrowing ability of entrepreneurs and, as result, reduces consumption, capital and housing. The latter serves as a mean of collateral and weakens demand on the housing market, which reduces the price of houses and the value of collateral. Such

Table 2. The Steady-State Ratios in the "Initial" and "Modified" Models

Ratio	Before Land Reform	After Land Reform
Investment-to-Output	0.14	0.14
Borrowing-to-Output (Households)	0.08	0.10
Borrowing-to-Output (Entrepreneurs)	0.35	0.81

Next, I examine the properties of the models with an impulse response function analysis. This provides an answer to how the magnitude of the shock amplification will be altered after the changes implied by land reform. The combined responses of 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) Land Reform



an amplification leads to an initially negative response to a technological shock. However, the estimated model for Ukraine cannot produce deflation of the required amplitude, so productivity drives output up, outweighing the consequences of debt-deflation.

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

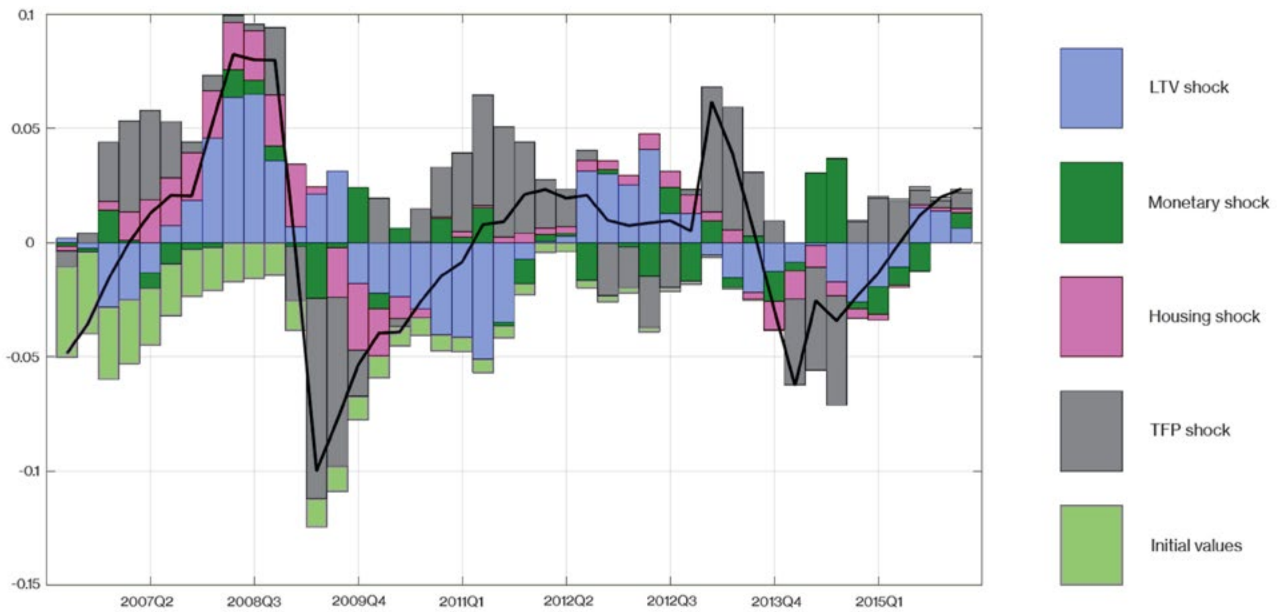
Due to its high persistence, the housing preference shock exerts a significant effect on the macroeconomic dynamics. A positive shock leads to higher demand for houses, which drives their prices up. This means a collateral constraint easing, which in turn allows a higher level of borrowing. Entrepreneurs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

The monetary and productivity shocks in both the initial and modified models lead to the same dynamics. Land and houses behave alike, with movements in the same direction, and with monetary and technological shocks producing a negligible difference across the models. However, the picture differs significantly in the case of a housing preference shock. The latter shock creates a higher oscillation of the collateral price (in comparison to other considered shocks, see Figure L1 (Appendix L) which is consistent with Liu, Wang and Zha (2013). As housing, as a factor of production, becomes 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 substantial differences across the models. The mechanism is rather straightforward: an increase of the loan-to-value ratio fosters collateral constraint easing, which enhances demand on all markets. Higher demand on the housing market leads to higher house prices, which, in its turn, further amplifies the shocks. In the case of an LTV shock, the dynamics of the macroeconomic indicators are directly affected by the amount of collateral. For this reason, the possibility of borrowing against land creates essential differences in the amplification as a result of land reform.

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

Figure 3. Historical Decomposition of the Output of Ukraine

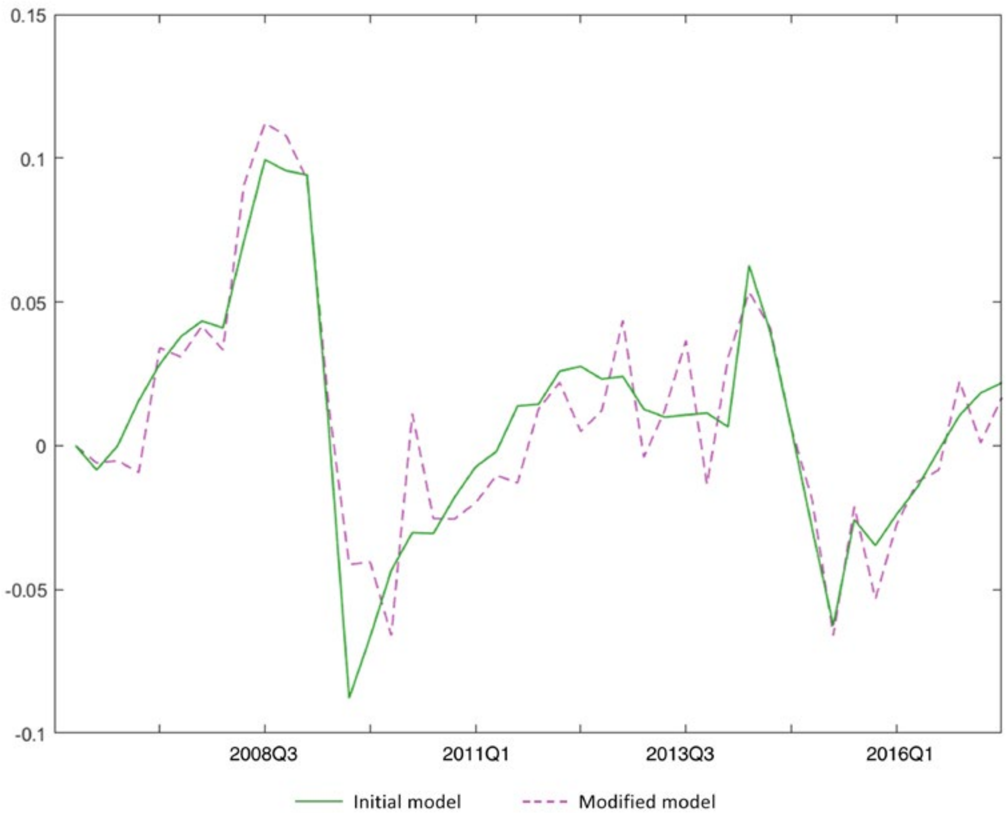


The historical decomposition of the output suggests that in 2009-2011 and 2013Q3-2015Q2 output was below its steady-state level, while between the recessions, GDP was slightly above its natural level with the peak occurring in 2013Q1. The downturn that happened in 2008 and that worsened during 2009 was driven by a negative TFP shock, accompanied by a negative housing preference shock and latter compounded by a loan-to-value shock that broadly incorporated all financial factors. As the economy is modeled as closed, a 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 a counterfactual experiment. Having obtained the historical decomposition of the output, I extract the historical shocks produced by the Kalman Smoother (Appendix L). 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 (which simulates the economy when the moratorium is lifted) and made it subject to the series of shocks produced by the Kalman Smoother to obtain an alternative scenario (Figure 4).

The discrepancy across the scenarios is a logical consequence arising 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 increases 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 in the alternative scenario. So, under certain conditions, land trade and land collateralization can both contribute to shock amplification, and alleviate its consequences, depending on the nature of the driving force of the output deviation.

Figure 4. Counterfactual Experiment. Actual Output (Solid) Versus Alternative (Dotted)



7. CONCLUSIONS

The final stage of the land reform in Ukraine entails the creation of the land market and the possibility of land collateralization. Treating land as a regular asset improves access to the financial market through the relaxation of borrowing constraints. In the context of the observed housing market spillover effects, that there will be changes in business cycle dynamics due to land collateralization seems to be a legitimate assumption.

To analyze the effect of the land reform on the business cycle, I extended Iacoviello (2005). Land is added to the framework as another factor of production, along with capital, labor and housing. With the aim of making a dynamic comparison, two models were constructed. The "Initial Model" is constructed such that land is distributed across economic agents and is not the subject to trade or collateralization. The "Modified Model" allows land to be traded and to borrowing against its value. The models were calibrated and estimated with Full Information Maximum Likelihood. The main findings are the following:

• Lifting the moratorium allows land to be traded and for it to be used as an additional way to secure loans. If there are binding borrowing constraints, additional collateral leads to constraint easing, which increases the borrowing power of impatient economic agents. It has been calculated that the overall Credit-to-GDP ratio would double, from about 0.45 to 0.90;

• Historical shock decomposition showed that technological and financial shocks made the biggest contribution to macroeconomic fluctuations; these shocks were also seen to be highly persistent;

• Land collateralization had a significant effect on the amplification magnitude in the case of a loan-to-value shock, as the amount of collateral affects the dynamics directly. Monetary and productivity shocks caused negligible changes in amplification in the counterfactual economy when land reform was implemented;

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

More accurate estimates would require the model to be augmented with elements that reflect the peculiarities of the Ukrainian economy. First, the introduction of the underground sector, which presumably tends to weaken the credit cycle, is reasonable in the case of an emerging economy. Second, the addition of the supply side of the housing market and growth trends similar to those of Iacoviello and Neri (2010) could refine model performance significantly. I anticipate that these two extensions would lead to a quantitative improvement. Overall, the main contribution of the present work is a conceptual assessment of the macroeconomic implications of the land market's emergence in Ukraine, with the focus being on credit cycle fluctuations, where tradable land could potentially be used as a means for extending collateralized credit.

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APPENDIX A. OPTIMIZATION PROBLEM OF PATIENT HOUSEHOLDS IN THE INITIAL MODEL

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

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

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

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

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{E^t} \ln c_t^E + \lambda_t^E \left(\frac{Y_t}{X_t} + b_t^E - c_t^E - q_t^h (h_t^E - h_{t-1}^E) - R_{t-1} \frac{b_{t-1}^E}{\pi_t} - w_t^I L_t^I - w_t^P L_t^P - r_t^I Z^I - r_t^P Z^P - I_t - \frac{\psi}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1} \right)$$
$$+ \mu_t^E \left(m_t \pi_{t+1} q_{t+1}^h h_t^E - R_t b_t^E \right) + u_t^E \left(I_t - K_t + (1-\delta) K_{t-1} \right) + s_t^E \left(A_t K_{t-1}^{\mu} h_{E,t-1}^{v} (Z_E^{\varphi} Z_P^{d} Z_I^{1-\varphi-d})^{u} \left(L_{P,t}^{\alpha} L_{I,t}^{1-\alpha} \right)^{1-\mu-u-v} - Y_t \right).$$

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:

$$\frac{1}{c_t^E} \left(1 + \frac{\psi_K}{\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right) \right) = E_t \left(\frac{\beta^E}{c_{t+1}^E} \frac{\mu Y_{t+1}}{X_{t+1} K_t} + (1-\delta) \frac{\beta^E}{c_{t+1}^E} \left(1 + \frac{\psi_K}{\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right) \right) - \frac{1}{c_{t+1}^E} \left(\frac{\psi_K}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right) - \frac{\psi_K}{\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right) \frac{I_{t+1}}{K_t} \right) \right).$$

Housing demand:
$$\frac{q_t^E}{c_t^E} = \left(\frac{\beta^E}{c_{t+1}^E} \frac{v Y_{t+1}}{X_{t+1} h_t^E} + \beta^E \frac{q_{t+1}^h}{c_{t+1}^E} + \left(\frac{1}{c_t^E R_t} - \beta^E \frac{1}{c_{t+1}^E \pi_{t+1}} \right) m_t^E \pi_{t+1} q_{t+1}^h \right).$$

APPENDIX D. OPTIMIZATION PROBLEM OF PATIENT HOUSEHOLDS IN THE MODIFIED MODEL

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^{P^t}\left(\ln c_t^P + j_t \ln h_t^P - \frac{L_t^{P^\eta}}{\eta}\right) + \lambda_t^E\left(b_t^P + w_t^P L_t^P + r_t^P Z_{t-1}^P + F_t + T_t^P - c_t^P - q_t^h(h_t^P - h_{t-1}^P) - q_t^Z(Z_t^P - Z_{t-1}^P) - R_{t-1}\frac{b_{t-1}^P}{\pi_t}\right).$$

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

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

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

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

$$+\lambda_t^E \left(\frac{Y_t}{X_t} + b_t^E - c_t^E - q_t^h(h_t^E - h_{t-1}^E) - q_t^Z(Z_t^E - Z_{t-1}^E) - R_{t-1}\frac{b_{t-1}^E}{\pi_t} - w_t^I L_t^I - w_t^P L_t^P - r_t^I Z_{t-1}^I + r_t^P Z_{t-1}^P - I_t - \frac{\psi}{2\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1}\right)$$

$$+\mu_t^E\left(m_t\pi_{t+1}\left(q_{t+1}^h h_t^E + q_{t+1}^Z Z_t^E\right) - R_t b_t^E\right) + u_t^E(I_t - K_t + (1-\delta)K_{t-1}) + s_t^E\left(A_t K_{t-1}^{\mu} h_{E,t-1}^{v}(Z_{E,t-1}^{\varphi} Z_{P,t-1}^{d} Z_{I,t-1}^{1-\varphi-d})^{u}\left(L_{P,t}^{\alpha} L_{I,t}^{1-\alpha}\right)^{1-\mu-u-v} - Y_t\right).$$

Demand for patient households' labor: $w_t^P = \dfrac{\alpha(1-\mu-v-u)Y_t}{X_t L_t^P}.$

Demand for impatient households' labor: $w_t^I = \dfrac{(1-\alpha)(1-\mu-v-u)Y_t}{X_t L_t^I}.$

Demand for patient households' land: $r_{t+1}^P = \dfrac{duY_{t+1}}{X_{t+1}Z_t^P}.$

Demand for impatient households' land: $r_{t+1}^I = \dfrac{(1-\varphi-d)uY_{t+1}}{X_{t+1}Z_t^I}.$

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

Optimal investment schedule:

$$\frac{1}{c_t^E}\left(1 + \frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)\right) = E_t\left(\frac{\beta^E}{c_{t+1}^E}\frac{\mu Y_{t+1}}{X_{t+1}K_t} + (1-\delta)\frac{\beta^E}{c_{t+1}^E}\left(1 + \frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)\right) - \frac{1}{c_{t+1}^E}\left(\frac{\psi_K}{2\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right) - \frac{\psi_K}{\delta}\left(\frac{I_t}{K_{t-1}} - \delta\right)\frac{I_{t+1}}{K_t}\right)\right).$$

Housing-consumption relation: $\dfrac{q_t^h}{c_t^E} = \left(\dfrac{\beta^E}{c_{t+1}^E}\dfrac{vY_{t+1}}{X_{t+1}h_t^E} + \beta^E\dfrac{q_{t+1}^h}{c_{t+1}^E} + \left(\dfrac{1}{c_t^E R_t} - \beta^E\dfrac{1}{c_{t+1}^E\pi_{t+1}}\right)m_t\pi_{t+1}q_{t+1}^h\right).$

APPENDIX G. THE STEADY-STATE RATIOS OF THE FINAL MODEL

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

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

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

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

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

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

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

APPENDIX H. EQUILIBRIUM DYNAMICS FOR THE INITIAL MODEL

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

where $\gamma_h = \beta^I + \beta^P m - \beta^I m$, $\gamma_e = \beta^E + \beta^P m - \beta^E m$.

APPENDIX I. THE STEADY-STATE RATIOS OF THE MODIFIED MODEL

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

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

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

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

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

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

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

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

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

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

APPENDIX J. EQUILIBRIUM DYNAMICS FOR THE MODIFIED MODEL

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX K. TABLES

Table K1. 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

Table K2. Calibration

Description	Parameter	Value
Patient household discount factor	β^p	0.995
Impatient household discount factor	β^i	0.980
Entrepreneur discount factor	β^e	0.940
Housing service utility weight	j	0.050
Frisch labor supply elasticity	η	2.000
Capital share	μ	0.250
Land share	u	0.030
Housing share	v	0.020
Capital depreciation	δ	0.030
Steady-state LTV ratio	m	0.310
Steady-state markup	X	1.100
Patient household wage share	α	0.640
Patient households' rent share	d	0.070
Entrepreneurs' rent share	φ	0.840
The Taylor rule parameter of inflation response	r_π	0.540
The Taylor rule inertia parameter	r_R	0.860
The Taylor rule parameter of output response	r_Y	0.000

Table K3. Estimation Results

Description	Parameter	Value	S.E.
Persistence of the technological shock	ρ_a	0.7719	0.1839
Persistence of the monetary shock	ρ_e	0.1447	0.0367
Persistence of the loan-to-value shock	ρ_m	0.9477	0.0262
Persistence 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 L. FIGURES

Figure L1. Asset Price Fluctuations Caused by One Standard Deviation of the Corresponding Shock

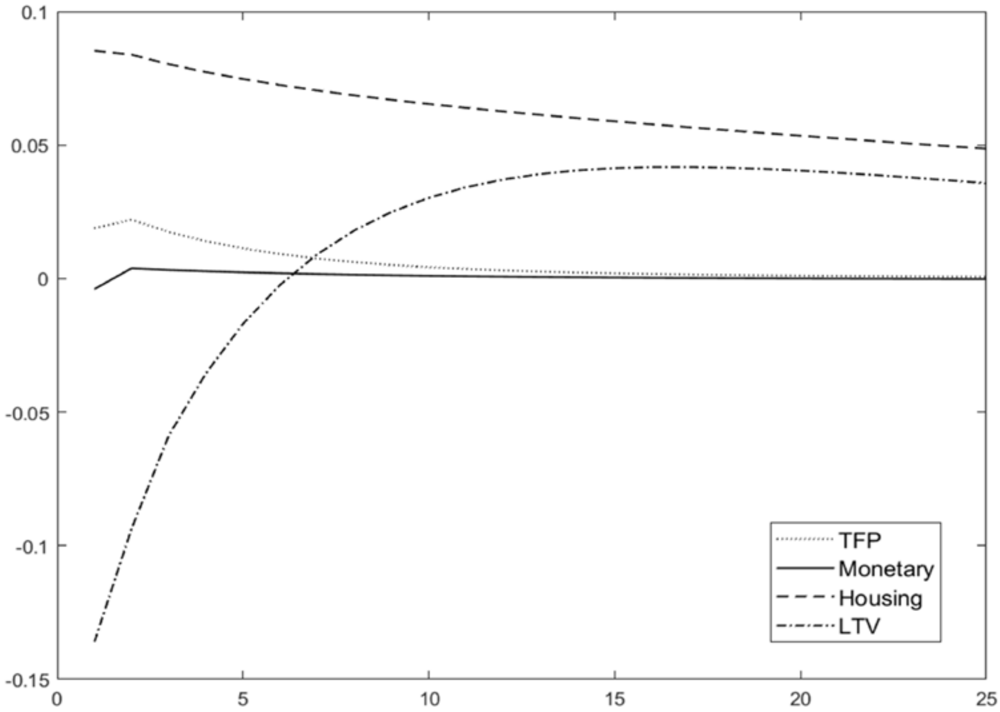

Figure L2. Smoothed Shocks

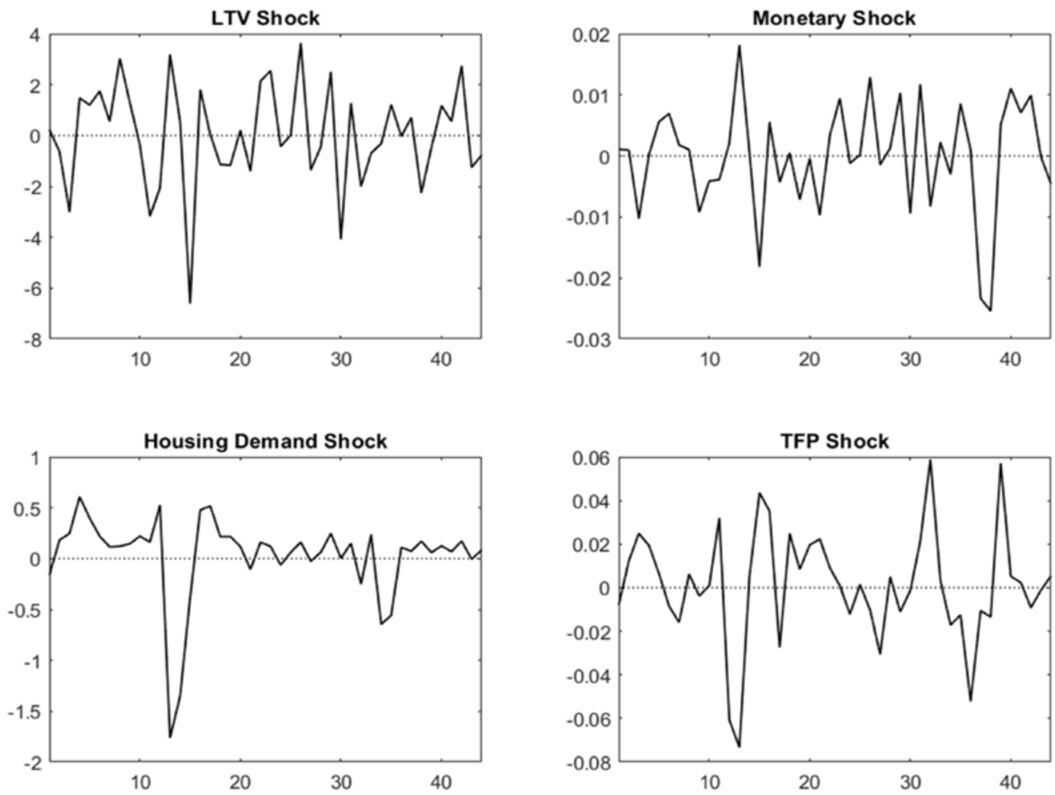

Figure L3. IRFs to TFP Shock of the Initial (Solid) and Modified (Dashed) Models

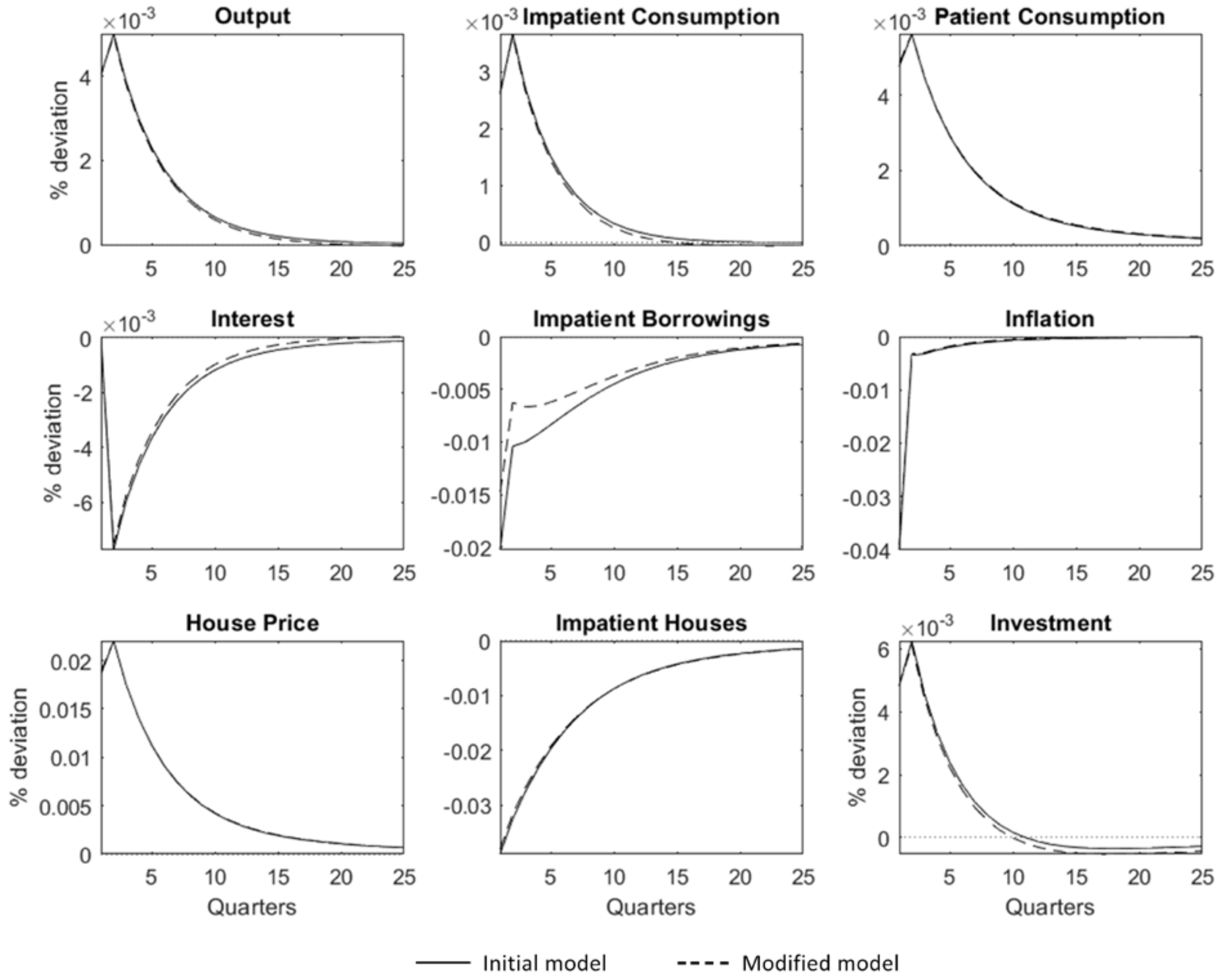

Figure L4. IRFs to Monetary Shock of the Initial (Solid) and Modified (Dashed) Models

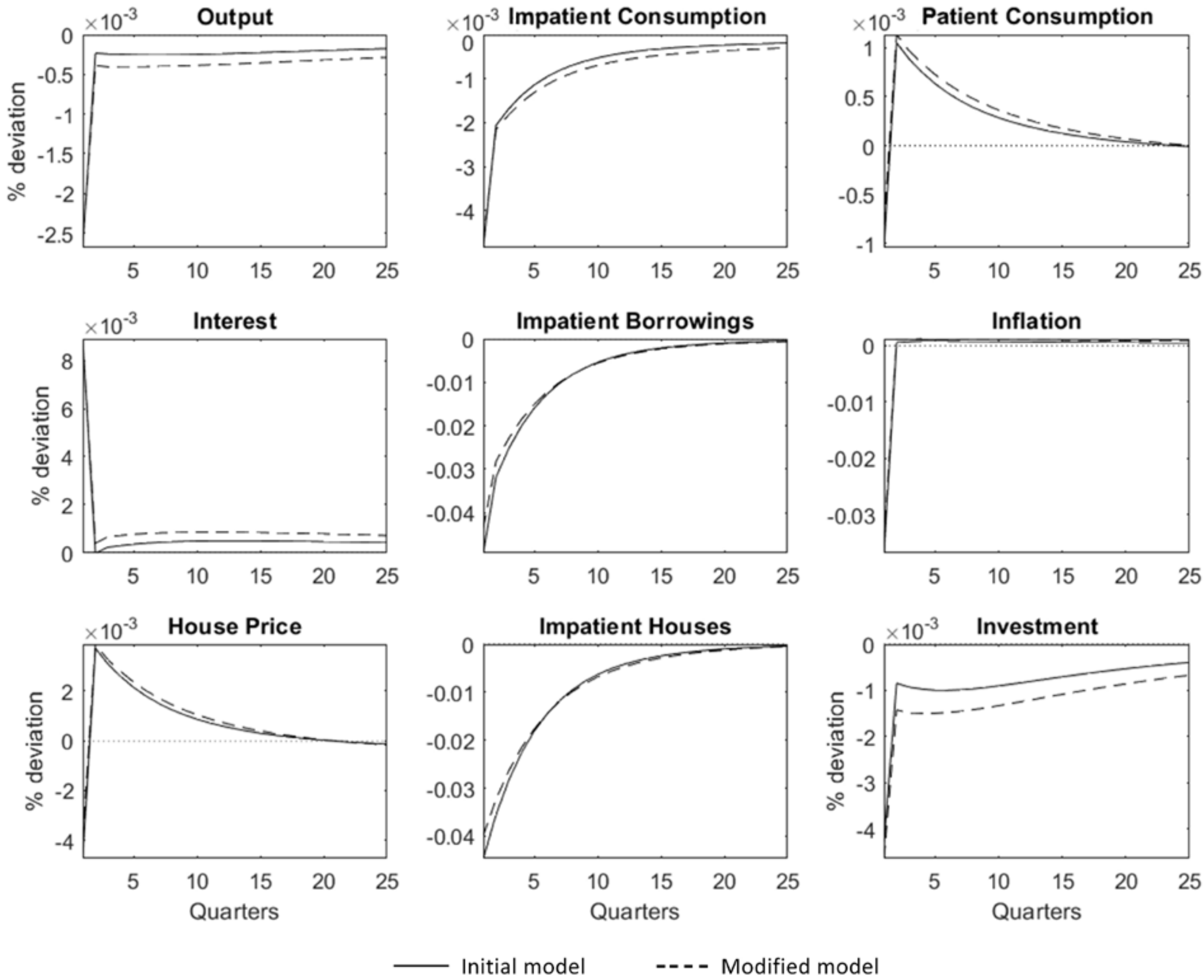

Figure L5. IRFs to House Preference Shock of the Initial (Solid) and Modified (Dashed) Models

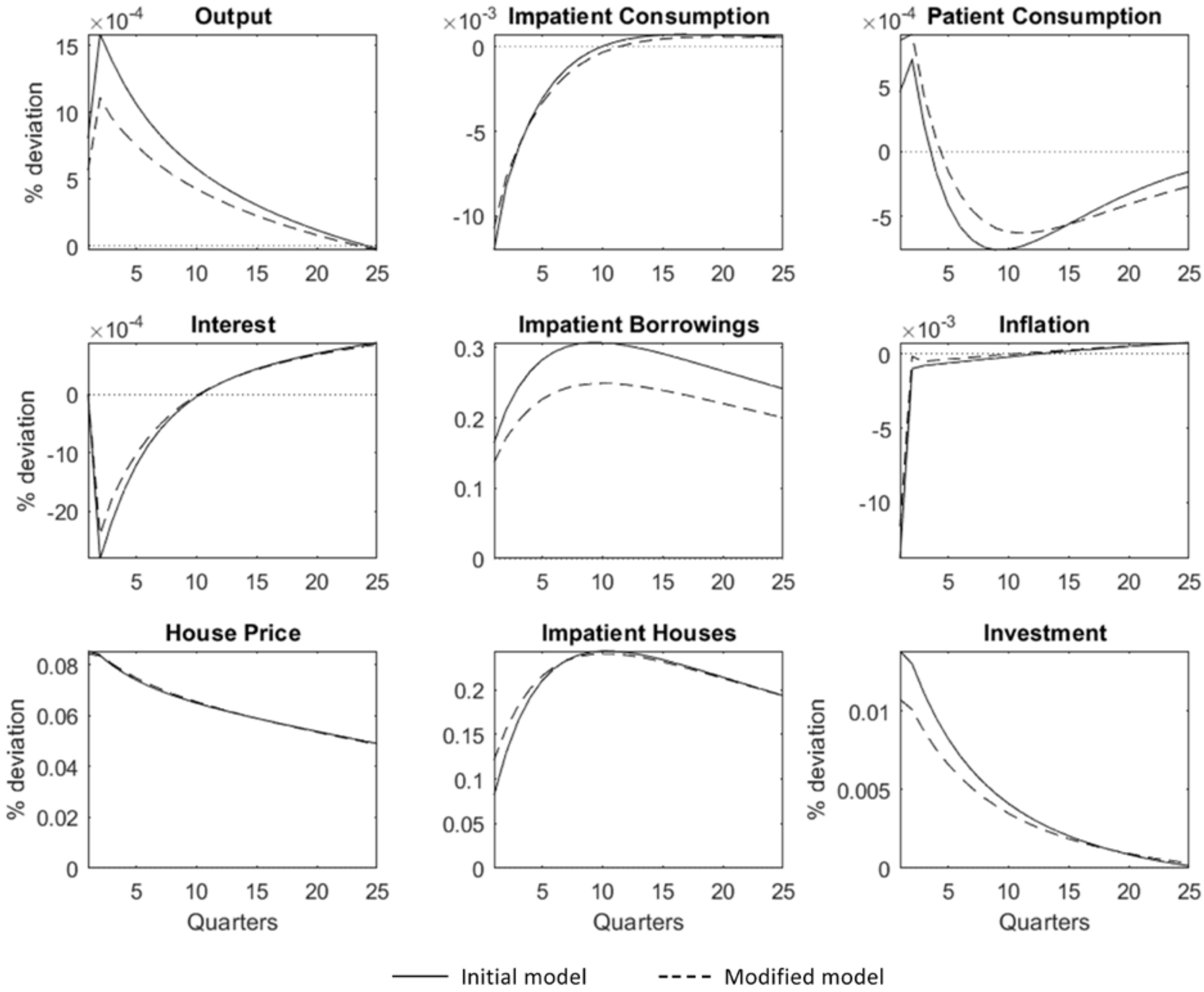

Figure L6. IRFs to LTV Shock of the Initial (Solid) and Modified (Dashed) Models