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The impact of macroeconomic policies to real estate market in People's Republic of China

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ABSTRACT

This paper develops a dynamic stochastic general equilibrium (DSGE) model with housing sector to study the effect of China's new policies to real estate market. The model is estimated by Bayesian Maximum Likelihood methods using ten macro-economic time series over the period Q1 1999 to Q4 2011. The results show that the property tax policy with focus on limiting housing demand by increasing households' cost of holding housing is good at controlling house prices, but it has a negative impact on housing firms. The land policy concentrated on adjusting housing supply by declining the land cost of housing firms is weak at diminishing housing prices, but it can promote the development of the housing sector and keep real estate market stable.

Keywords: DSGE models, policy analysis, China, housing

JEL Classification: E32, E62, R31, R38

1. Introduction

In recent years, the real estate market became overheated. In order to stabilize the rapidly expanding housing market, the Chinese government has issued a series of new policies. These policies can be summarized into four main categories: The first policy is land policy which is aimed to stabilize land costs. Land costs are the main component of housing prices. According to Du et al. (2011), high land cost is one of the primary factors causing housing prices to rise so quickly in China in recent years. The land policy is implemented in two ways: one is reducing speculation of land by increasing security money and access threshold of land auction and the other is increasing supply of land by reclaiming undeveloped land.

The second policy is monetary policy with an objective to reduce the availability of loans by reducing commercial banks' amount of credit and increases costs of loans. Monetary policy has been used frequently by People's Bank of China in a way that changes the deposit reserve ratio and the base rate. Numerous studies have attempted to explain the impact of monetary policy on the housing sector. Ahearne et al. (2005) found that housing price booms are preceded by loose monetary policy. Allen and Carletti (2010) suggested that interest rates can be used as an instrument to prevent housing bubbles in small homogeneous economies. The recent study of Miu (2011) showed that housing prices are mostly influenced by loan interest rate. So in this study, we only focus on the loan interest rate.

The next policy is property tax policy which focusing on increasing the cost of holding housing by changing property tax rate. There is substantial empirical evidence that property taxes will cause a significant negative impact on the housing sector (Goulder, 1989; Skinner, 1996a; Capozza et al., 1998). We know its effect but nothing about its degree and horizon, so the property tax is still in the pilot phase in China, and has only been tested in two cities.

The last one is an affordable housing policy, which is implemented by governments that invest in the housing sector to provide more affordable housing or control its scale.

The purpose of the four main policies is to decline the house prices and keep the housing market stable. Decreasing house price is a main way to eliminate potential bubbles. Meanwhile, a stable housing market will guarantee that when house prices fall, the bubble will not burst in the future and cause housing collapse.

This paper aims at analyzing the effect of these four policies on real estate market using a dynamic stochastic general equilibrium (DSGE) model with housing sector. We have selected a DSGE framework as a tool for policy analysis for three reasons: (1) DSGE models are built on macroeconomic foundation and focus on agents' intertemporal choice; (2) the models' general equilibrium nature can capture the interaction between policy actions and agents' behavior; and (3) DSGE models allow examination of multiple shocks and trace their transmission to the economy.

Our work builds on recent attempts to model the real estate market using the current generation of micro-founded DSGE models. For instance, Funke and Paetz (2010) and Bao (2010) developed an open-economy DSGE model with housing-market sector to obtain the effects of a number of shocks on the housing sector. Paries and Notarpietro (2010) estimated a two-country DSGE model for the US and the Euro area including relevant housing market features to examine the monetary policy implications of housing-related disturbances. Iacoviello and Neri (2008) built a two-sector model to quantify the contribution of the housing market to business fluctuations. In China, The existing literature of DSGE models has focused mainly on the interaction between real estate market and monetary policy (Xiao and Pen, 2011; Li et al., 2011; Liu and Yuan, 2011). Compared with previous studies, our main contribution is to introduce three fiscal policies (land policy, housing tax policy and affordable housing policy) into the DSGE model and analyze their effects on real estate market, thus, bridge the gap between policy analysis of housing market and DSGE framework.

The remainder of this paper is organized as follows. Section 2 describes the DSGE model, giving proper consideration to China's characteristics with emphasis on descriptions of the housing sector and policy mechanism. Section 3 shows the parameter estimations including description of data, calibration, prior distributions and posterior distributions. An analysis of impulse responses to several policy shocks is presented in Section 4. Section 5 provides some conclusions.

2. The DSGE Model

2.1 Households

(1) Patient Households

The representative patient households (Lenders) are infinitely-lived and seek to maximize

$$E_0\sum_{t=0}^{\infty}\left(\beta G_C\right)^t z_t\left(\Gamma_c \log\left(c_t-\varepsilon c_{t-1}\right)+j_t\log h_t-\frac{\tau_t}{1+\eta}\left(n_{c,t}^{1+\xi}+n_{h,t}^{1+\xi}\right)^{\frac{1+\eta}{1+\xi}}\right) \quad (1)$$

where c, h, n_c, n_h represent consumption, housing, hours in the consumption sector and hours in the housing sector. β denotes the discount factor. E is the expectation operator and G_C is the gross growth rate of consumption along the balanced growth path. The scaling factors $\Gamma_c=(G_C-\varepsilon)/(G_C-\beta\varepsilon G_C)$ ensure that the marginal utilities of consumption are $1/c$ in the steady state. η measures the inverse Frisch elasticity of labor supply and ε is the degree of habit formation in consumption. The parameter ξ describes the inverse elasticity of substitution across hours. Random variations in z_t, j_t and τ_t capture respectively shocks to intertemporal preferences, to the demand for housing and to the supply of labor. These shocks follow the stochastic processes:

$$\ln z_t=\rho_z\ln z_{t-1}+\mu_{z,t}, \qquad \mu_{z,t}\sim N\left(0,\sigma_z\right) \quad (2)$$

$$\ln j_t=\left(1-\rho_j\right)\ln\overline{j}+\rho_j\ln j_{t-1}+\mu_{j,t}, \qquad \mu_{j,t}\sim N\left(0,\sigma_j\right) \quad (3)$$

$$\ln \tau_t=\rho_\tau\ln \tau_{t-1}+\mu_{\tau,t}, \qquad \mu_{\tau,t}\sim N\left(0,\sigma_\tau\right) \quad (4)$$

where ρ_z, ρ_j, ρ_τ measure the persistence of those shocks, and $\mu_{z,t}$, $\mu_{j,t}$, $\mu_{\tau,t}$ are independent and identically distributed i. i. d.

Each period, patient households maximize their lifetime utility subject to the following budget constraint:

$$c_t + \frac{k_{c,t}}{A_{k,t}} + k_{h,t} + q_t h_t + b_t + k_{b,t} = \frac{w_{c,t}}{X_{wc,t}} n_{c,t} + \frac{w_{h,t}}{X_{wh,t}} n_{h,t}$$
$$+ \left(R_{c,t} + \frac{1-\delta_{kc}}{A_{k,t}} \right) k_{c,t-1} + \left(R_{h,t} + 1 - \delta_{kh} \right) k_{h,t-1} + p_{b,t} k_{b,t} \quad (5)$$
$$+ \frac{R_{t-1} b_{t-1}}{\pi_t} + \left(1-\delta_h\right) q_t h_{t-1} + f_t - \psi_{h,t} q_t h_t - \phi_t$$

Patient households obtain wages from working in two sectors (working hours $n_{c,t}$ and $n_{h,t}$), lump-sum profits f_t from final good firms and labor unions, rental income from holding consumption capital $k_{c,t}$ and housing capital $k_{h,t}$, and interest from offering one-period loans b_{t-1} to impatient households. And then subject to this resource constraint, they choose plans for consumption c_t, intermediate goods $k_{b,t}$, one-period loans b_t and investment in consumption capital, housing capital and housing h_t (priced at q_t) to maximize their utility. $w_{h,t}$, $w_{c,t}$, $R_{h,t}$, $R_{c,t}$, δ_{kh}, δ_{kc} denote real wage, capital rental rates and depreciation rates in housing and consumption sector. R_t is riskless nominal return rate of loan. $A_{k,t}$ captures investment-specific technological shocks. $X_{wc,t}$ and $X_{wh,t}$ denote the makeup between the wage paid by the wholesale firm and the wage paid to the household, which accrues to the labor unions ($X_{wc,t} = w_{c,t}/w_{c,t}^{w}$, $X_{wh,t} = w_{h,t}/w_{h,t}^{w}$). $\pi_t = P_t/P_{t-1}$ is the gross money inflation rate in the consumption sector. f_t is lump-sum profits from final good firms and from labor unions, $\emptyset_t$ denotes convex adjustment costs for capital and ψ_h is the housing tax rate.

(2) Impatient Household

The representative impatient households (Borrowers) are expressed by the variables with a prime and their optimization problem is to maximize

$$E_0 \sum_{t=0}^{\infty} \left(\beta' G_C\right)^t z_t \left(\Gamma_c' \log\left(c_t' - \varepsilon' c_{t-1}'\right) + j_t \log h_t' - \frac{\tau_t}{1+\eta'} \left(\left(n_{c,t}'\right)^{1+\xi'} + \left(n_{h,t}'\right)^{1+\xi'} \right)^{\frac{1+\eta'}{1+\xi'}} \right) \quad (6)$$

subject to

$$c_t' + q_t h_t' + \frac{R_{t-1}}{\pi_t} b_{t-1}' = \frac{w_{c,t}'}{X_{wc,t}'} n_{c,t}' + \frac{w_{h,t}'}{X_{wh,t}'} n_{h,t}' + b_t' + \left(1-\delta_h\right) q_t h_{t-1}' + f_t' - \psi_{h,t} q_t h_t' \quad (7)$$

where

$$b_t' \le m E_t \left(q_{t+1} h_t' \pi_{t+1} / R_t \right) \quad (8)$$

Impatient households do not accumulate capital and do not own finished good firms (their lump-sum profits f_t' come only from labor unions), and their only form of wealth will be their houses. In addition, the maximum amount they can borrow, $\acute{b}_t$, is affected by house collateral and the loan-to-value ratio is denoted as m.

(3) Wage Stickiness

Sticky wages are introduced into the labor market by assuming wage rigidity at the union level and the implicit costs of adjusting nominal wages following Calvo-style contracts that a fraction $1-\theta_{wi}$ of unions in each sector set wages optimally while others cannot do so in each period. The unions received labor services from patient and impatient households homogeneously at the wage w_t^w, differentiated labor services as in Smets and Wouters (2007), reassembled these services into the homogeneous labor composites $n_c, n_h, \acute{n}_c, \acute{n}_h$ and supplied them at a markup over the marginal cost to the firms. These assumptions deliver the following wage Phillips curves:

$$\omega_{c,t}-\iota_{wc}\log\pi_{t-1}=\beta G_C\left(E_t\omega_{c,t+1}-\iota_{wc}\log\pi_t\right)-\varepsilon_{wc}\log\left(X_{wc,t}/X_{wc}\right) \quad (9)$$

$$\omega'_{c,t}-\iota_{wc}\log\pi_{t-1}=\beta' G_C\left(E_t\omega'_{c,t+1}-\iota_{wc}\log\pi_t\right)-\varepsilon'_{wc}\log\left(X_{wc,t}/X_{wc}\right) \quad (10)$$

$$\omega_{h,t}-\iota_{wh}\log\pi_{t-1}=\beta G_C\left(E_t\omega_{h,t+1}-\iota_{wh}\log\pi_t\right)-\varepsilon_{wh}\log\left(X_{wh,t}/X_{wh}\right) \quad (11)$$

$$\omega'_{h,t}-\iota_{wh}\log\pi_{t-1}=\beta' G_C\left(E_t\omega'_{h,t+1}-\iota_{wh}\log\pi_t\right)-\varepsilon'_{wh}\log\left(X_{wh,t}/X_{wh}\right) \quad (12)$$

where $\omega_{i,t}=w_{i,t}-w_{i,t-1}+\pi_t$ denotes nominal wage inflation for each sector-household pair. ι_{wi} represents the elasticity between index wage and the previous period inflation rage in each sector. $\varepsilon_{wc}=(1-\theta_{wc})(1-\beta G_C\theta_{wc})/\theta_{wc}$,
$\acute{\varepsilon}_{wc}=(1-\theta_{wc})\left(1-\acute{\beta} G_C\theta_{wc}\right)/\theta_{wc}$, $\varepsilon_{wh}=(1-\theta_{wh})(1-\beta G_C\theta_{wh})/\theta_{wh}$ and $\acute{\varepsilon}_{wh}=(1-\theta_{wh})\left(1-\acute{\beta} G_C\theta_{wh}\right)/\theta_{wh}$.

2.2 Firms

There are two sectors on the supply side. Consumption goods sector produces final goods for consumption with monopolistic power and intermediate inputs for the housing sector. Housing sector produces new houses using labor, land, housing capital and intermediate inputs.

(1) Consumption Goods Sector

The wholesale firms hire labor and rent capital to produce intermediate goods Y_t in order to maximize profits:

$$\max\frac{Y_t}{X_t}-\left(w_{c,t}n_{c,t}+w'_{c,t}n'_{c,t}+R_{c,t}k_{c,t-1}\right) \quad (13)$$

Intermediate goods (nominal price P_t^w) are then transformed into final goods (priced at P_t) from final goods firms. So we define $X_t=P_t/P_t^w$ as the markup of final over intermediate goods. The production technology is:

$$Y_t = \left(A_{c,t}\left(n_{c,t}^{\alpha} n_{c,t}'^{1-\alpha}\right)\right)^{1-v_c} k_{c,t-1}^{v_c} \qquad (14)$$

where $A_{c,t}$ is a measure of productivity in the consumption goods sector. v_c denotes outcome share of capital in consumption sector

We assume monopolistic competition in the consumption goods sector. The final goods firms buy wholesale goods Y_t from wholesale firms at the price P_t^w in a competitive market, differentiate the goods at no cost, set prices subject to a Calvo price and sell them to the two kinds of households. Under Calvo pricing with partial indexation to past inflation, the pricing rules set by the final goods firms imply the price Phillips curve that is isomorphic to the wage Phillips curve.

$$\log \pi_t - \iota_\pi \log \pi_{t-1} = \beta G_C\left(E_t \log \pi_{t+1} - \iota_\pi \log \pi_t\right) - \varepsilon_\pi \log\left(X_t / X\right) + \log \mu_{p,t} \quad (15)$$

where $\varepsilon_\pi = (1-\theta_\pi)(1-\beta G_C \theta_\pi)/\theta_\pi$. As in Smets and Wouters (2007), we allow for cost-push shocks that affect inflation independently from fluctuations in the real marginal cost. These shocks are assumed to be i.i.d. with zero mean and variance equal to σ_p^2.

(2) Housing Sector

In housing sector, firms solve the following problem:

$$\max q_t IH_t - \left(w_{h,t} n_{h,t} + w'_{h,t} n'_{h,t} + R_{h,t} k_{h,t-1} + p_{l,t-1} l_{t-1} + p_{b,t} k_{b,t}\right) \qquad (16)$$

where

$$IH_t = \left(A_{h,t}\left(n_{h,t}^{\alpha} n_{h,t}'^{1-\alpha}\right)\right)^{1-v_h-v_b-v_l} \left(k_{h,t-1} + G_{i,t-1}\right)^{v_h} k_{b,t}^{v_b} l_{t-1}^{v_l} \qquad (17)$$

The representative firm use labor (n_h and n'_h), capital in housing sector, k_h, government investment, $G_{i,t}$, land, l_t and the intermediate input, $k_{b,t}$ produced in consumption goods sector to produce new houses IH_t. The term $A_{h,t}$ is a measure of productivity in the housing sector. α denotes the labor income share of unconstrained households. v_h, v_b and v_l represent the outcome share of capital, intermediate input and land.

Different from consumption goods sector, we rule out price rigidities in housing sector. The reason is that: First, most new houses are priced for the first time when they are sold. Second, housing firms cannot increase the housing price after they priced according to China's new real estate policy.

2.3 Government

The government employs four policies to manage the economy: the affordable housing policy is defined as an investment in housing production; the land policy is considered as a change in land cost, adjustment of housing tax is used to describe the property tax policy, and the monetary policy aims to increase the loan interest rate.

(1) Affordable Housing Policy and Tax Policy

To implement an affordable housing policy and tax policy, every period the government spends $G_{e,t}$ on consumption goods, and invests $G_{i,t}$ in the housing sector as capital input. The revenue of government comes from two parts: housing taxes from two kinds of households and land income. The government budget constraint is:

$$G_t = \psi_{h,t} q_t \left(h_t + h_t'\right) + p_{l,t-1} l_{t-1} \tag{18}$$

$$G_{i,t} = \left(1-\theta_g\right) G_t + g_t \tag{19}$$

$$G_{e,t} = \theta_g G_t \tag{20}$$

$$\ln g_t = \left(1-\rho_g\right) \ln \bar{g} + \rho_g \ln g_{t-1} + \mu_{g,t} \tag{21}$$

where $G_t$is the total government expenditure, $G_{i,t}$ and $G_{e,t}$ represent the government expenditure in housing sector and consumption sector. $\psi_{h,t}$ is property tax rate. g_t captures a fiscal expenditure (we define it as a deficit). The term $\mu_{g,t}$ captures a zero-mean, i.i.d. affordable housing policy shock with variance σ_g^2.

For tax policy, when the government increases the property tax rate, the households need to spend more money on holding houses, which will decrease their preference of holding and purchasing houses, thus curb speculation. The function of housing tax shock is shown as follows:

$$\ln \psi_{h,t} = \left(1-\rho_h\right) \ln \bar{\psi} + \rho_h \ln \psi_{h,t-1} + \mu_{h,t} \tag{22}$$

(2) Land Policy

The land policy in China is different from other countries. First, the land is publicly owned, not private, and the land income is an important source of government revenues. Second, the land cost is determined by auction. So we assume land cost is stochastic to capture the feature of land policy.

$$p_{l,t} = p_{l,t-1}^{\rho_{pl}} \frac{\mu_{pl,t}}{e_t} \tag{23}$$

where $p_{l,t}$ is price of land for housing sector, ρ_{pl} is the smoothing parameter, and the term $\mu_{pl,t}$ captures independent and identically distributed postitive land cost shock with mean zero and variance σ_{pl}^2, while e_t is a stochastic process in order to model the land policy.

$$\ln e_t = \rho_e \ln e_{t-1} + \mu_{e,t}, \qquad \mu_{e,t} \sim \left(0, \sigma_e\right) \tag{24}$$

The land policy is aimed to decline land cost by increasing security money of land auction, curbing land hoarding and testing the utilization ratio of land, thus the land cost will stay in a normal level. With lower land cost, the housing firms can produce more houses and make housing prices down.

(3) Monetary Policy

About the monetary policy, we assume that the government follows a Taylor rule which responds to inflation and GDP growth to adjust the interest rate R_t:

$$R_t = R_{t-1}^{r_R} \pi_t^{(1-r_R)r_\pi} \left(\frac{GDP_t}{G_C GDP_{t-1}} \right)^{(1-r_R)r_Y} \overline{rr}^{1-r_R} \mu_{R,t} \qquad (25)$$

where $\overline{rr}$ is the steady-state real interest rate (which we assume to be equal to $1/\beta$, the patient households discount rate), The term $\mu_{R,t}$ which captures a monetary policy shock follows a normal distribution with zero mean and finite standard deviation σ_R.

In monetary policy, impatient households' amount of loan is affected by interest rate. Once the interest rate increase, the loan amount of borrowers will decrease, which can limit purchase of housing, and then cool the real estate market.

2.4 Market Equilibrium

There are three markets in the model. The goods market produces consumption (households and government), investment in two sectors and intermediate inputs for the housing market. The housing market produces new homes for the two kinds of households. In the loan market, impatient agents rent one-period collateralized nominal loans from patient households. The three market clearing conditions are:

$$C_t + IK_{c,t}/A_{k,t} + IK_{h,t} + G_{e,t} + k_{b,t} = Y_t - \phi_t \qquad (26)$$

$$h_t + h'_t - (1-\delta_h)(h_{t-1} + h'_{t-1}) = IH_t \qquad (27)$$

$$b_t = b'_t \qquad (28)$$

where $C_t = c_t + \acute{c}_t$ is aggregate consumption, $IK_{c,t} = k_{c,t} - (1-\delta_{kc})k_{c,t-1}$ and $IK_{h,t} = k_{h,t} - (1-\delta_{kh})k_{h,t-1}$ are the two components of business investment, expressed in real units. $G_{e,t}$ is government expenditure.

3. Parameter Estimation

The model is estimated by using Bayesian methods. The aim of the Bayesian estimation is to obtain posterior distributions of the parameters and make inference out of them. To do so, the data should be transformed into a suitable form for the computation of the likelihood function using the state-space representation of the model that can be analyzed with a Kalman filter. Then, together with the specification of prior distributions for the parameters, the posterior distributions can be derived on the basis of Bayes theorem as follows

$$p(\theta|Y) \propto L(\theta|Y)p(\theta)$$

where $p(\theta|Y)$ and $p(\theta)$ denote the posterior and prior distribution of the parameters, and $L(\theta|Y)$ is the likelihood function of the observed data Y. The term $\propto$ represents proportionality. Since the posterior is difficult to characterize, we use the Metropolis-Hastings algorithm to simulate it and obtain point estimates and standard deviations.

3.1 Description of Data

Ten macroeconomic quarterly series over the period Q1 1999 to Q4 2011: consumption, real estate investment, capital investment, labor in consumption, labor in housing sector, house price, interest rate, inflation, wage in consumption sector and wage in housing sector are used in the study. Inflation is measured by using the quality-adjusted CPI index. The capital investment is represented by fixed-asset investment. The National Housing Sensitive index is used as the measure of the real house price and the 1-year loan interest rate is applied to capture the loan interest rate. All variables are from the Statistics Bureau of China and already being tested to be stationary by using log difference and HP filter following standard practice.

3.2 Calibration

A number of parameters are excluded from the estimation and need to be calibrated. This is because they are either notoriously difficult to estimate or better be identified by using other information. As in Li et al. (2011), the discount factor for patient households is fixed at 0.984, implying a steady state real interest rate of around 6 percent on an annual basis and we choose a value 0.97 for impatient households to guarantee a large enough impatience motive. The parameter of housing preference is set to 0.16 in order to match the real estate share of GDP in China. Following Wang and Zhu (2009), the capital share in consumption sector is fixed at 0.436. In housing sector, we set the share of housing capital, land and intermediate goods are all equal to 0.2. Markups are set to 1.15 in both goods markets and labor market (in each sector) as in Iacoviello (2008). The depreciation rate for housing is equal to 0.01, corresponding to an annual rate of 4%, whereas the depreciation rate of consumption capital and housing capital are set to 0.025 and 0.03. The loan-to-value ratio is taken from Xiao and Peng (2011), and the share of consumption expenditure in government revenues is fixed at 0.95 according to the actual time series data of China's economy.

Table 1 Calibration

Parameter	Value	Description
β, β'	0.984, 0.97	Subjective discount factor
$X, X_{wc,t}, X_{wh,t}$	1.15	Markup of gross price and wage
j	0.16	Housing preference
ν_c, ν_h	0.436, 0.2	Capital share in both sectors
ν_b, ν_l	0.2	Share of land and intermediate goods
$\delta_h, \delta_{kc}, \delta_{kh}$	0.01, 0.025, 0.03	Depreciation of housing and capital
m	0.7	Loan-to-value ratio
θ_g	0.95	Share of consumption expenditure

3.3 Prior Distributions

The prior distributions of parameters in this study are either consistent with the previous literature or relatively uninformative. The standard errors of the shocks are assumed to follow a uniform distribution with a mean of 3 and 1.7 degrees of freedom, while the persistence parameters are beta distributed with mean 0.8 and standard deviation 0.1. For the parameters of monetary policy which is based on a standard Taylor rule, we follow Sun and Sen (2010), the interest rate smoothing parameter is set as a beta distribution with mean 0.75 and standard errors 0.1, and the parameters capturing the response to changes in inflation and output gap are described by a Normal distribution around a mean of 1.63 and 0.01 with a standard error of 0.05.

Table 2 Prior and Posterior Distribution of the Structural Parameters

	Prior Distribution			Posterior Distribution			
Parameter	Distr.	Mean	St.Dev	Mean	CI(low)	Median	CI(high)
ε	Beta	0.61	0.075	0.5743	0.5501	0.5730	0.5958
$\acute{\varepsilon}$	Beta	0.61	0.075	0.9367	0.9084	0.9359	0.9633
α	Beta	0.5	0.05	0.2719	0.2421	0.2671	0.2920
θ_π	Beta	0.85	0.05	0.6851	0.6628	0.6845	0.7061
θ_{wc}	Beta	0.6	0.05	0.5597	0.5216	0.5578	0.5939
θ_{wh}	Beta	0.6	0.05	0.5768	0.5582	0.5820	0.6058
ι_π	Beta	0.5	0.2	0.8793	0.7968	0.8753	0.9537
ι_{wc}	Beta	0.5	0.2	0.6392	0.5603	0.6311	0.7019
ι_{wh}	Beta	0.5	0.2	0.5635	0.3735	0.5806	0.7877
r_R	Beta	0.75	0.1	0.6207	0.5676	0.6178	0.6680
η	Gamma	0.5	0.1	0.3513	0.3184	0.3514	0.3844
$\acute{\eta}$	Gamma	0.5	0.1	0.6616	0.5210	0.6625	0.8040
ξ	Normal	1	0.1	0.0030	-0.0262	0.0029	0.0320
$\acute{\xi}$	Normal	1	0.1	-1.2838	-1.3791	-1.2761	-1.1731
r_Y	Normal	0.01	0.05	0.0226	0.0036	0.0264	0.0491
r_π	Normal	1.68	0.05	1.2506	1.1965	1.2540	1.3115

The parameters in utility functions are assumed to be distributed as follows. The habit parameters of consumption in the two sectors are set at 0.61 with a standard error of 0.075, which is close to the estimates of Liang and Li (2011); the inverse elasticity of labor supply is common to both household types, following a Gamma distribution with mean 0.5 and standard deviation 0.1, and the elasticity of substitution across hours for both households has a Normal (1, 0.1) prior distribution. In production function, the Calvo parameters for price setting, following Liu (2008) is set to 0.85 as a Beta distribution, whereas the Calvo parameters for wage setting in both sectors are set around 0.6. The indexation parameters are distributed according to a Beta (0.5, 0.2) prior distribution, as in Smets and Wouters (2007). Finally, we set the parameters capturing the income share of patient household as a Beta distribution with parameters 0.5 and 0.05.

Table 3 Prior and Posterior Distribution of the Shock Processes

	Prior Distribution			Posterior Distribution			
Parameter	Distr.	Mean	St.Dev	Mean	CI(low)	Median	CI(high)
ρ_{ah}	Beta	0.8	0.1	0.9494	0.9350	0.9500	0.9650
ρ_{ac}	Beta	0.8	0.1	0.9902	0.9837	0.9904	0.9971
ρ_{ak}	Beta	0.8	0.1	0.5746	0.5186	0.5765	0.6343
ρ_z	Beta	0.8	0.1	0.8256	0.7508	0.8201	0.8893
ρ_j	Beta	0.8	0.1	0.4593	0.4074	0.4580	0.5085
ρ_τ	Beta	0.8	0.1	0.9694	0.9553	0.9698	0.9843
ρ_e	Beta	0.8	0.1	0.8535	0.7798	0.8555	0.9311
ρ_h	Beta	0.8	0.1	0.9987	0.9978	0.9988	0.9997
σ_z	Uniform	3	1.7	0.2810	0.2337	0.2826	0.3315
σ_j	Uniform	3	1.7	5.7046	5.3310	5.6378	5.9445
σ_τ	Uniform	3	1.7	0.4482	0.3551	0.4478	0.5405
σ_{ac}	Uniform	3	1.7	0.0764	0.0555	0.0759	0.0962
σ_{ak}	Uniform	3	1.7	0.2050	0.1551	0.2042	0.2532
σ_{ah}	Uniform	3	1.7	2.6702	2.1343	2.7130	3.2916
σ_p	Uniform	3	1.7	0.0578	0.0555	0.0581	0.0607
σ_e	Uniform	3	1.7	4.4937	3.6990	4.6122	5.5253
σ_R	Uniform	3	1.7	0.0570	0.0555	0.0572	0.0589
σ_{pl}	Uniform	3	1.7	5.5456	5.2799	5.6121	5.9443
σ_g	Uniform	3	1.7	0.5211	0.0556	0.5516	1.0476
σ_h	Uniform	3	1.7	1.8212	1.5389	1.8259	2.1128

3.4 Posterior Distributions

Tables 2 and 3 show the posterior mean and the 10th and 90th probability intervals for the structural parameters obtained using the Metropolis-Hastings algorithm. Some of the results are significantly different to prior findings. The labor income share of patient households is estimated at 0.2719, a value which is lower than our prior mean. The value of the habit in consumption is larger for impatient households ($\acute{\varepsilon} = 0.9367$, as opposed to $\varepsilon = 0.5743$ for the patient ones). For the labor supply elasticity parameters, the posterior means are 0.3513 and 0.6616, respectively for patient lenders and impatient borrowers.

The estimated mean for the interest rate smoothing parameter is 0.6207, which is similar to the prior mean (0.7). The value of the parameters describing the response to output growth and inflation are 0.0226 and 1.2506, which shows a small response to GDP growth and tightly response to inflation.

The shock of housing tax is quite persistent, with autocorrelation coefficients 0.9987. Meanwhile, the shocks of land cost and government investment are not persistent, and their autocorrelation coefficients are equal to 0.8535 and 0.7820.

About the nominal rigidities parameter, the estimate of θ_π is 0.6851, which implies that prices in the consumption goods sector are re-optimized infrequently. The wage stickiness in the consumption goods sector ($\theta_{wc} = 0.5597$) is lower than in the housing sector ($\theta_{wh} = 0.5768$), which means that the wage in the consumption goods sector adjusts frequently. Meanwhile, the wage indexation is larger in housing sector ($\iota_{wc} = 0.6392$ and $\iota_{wh} = 0.5635$).

4. Properties of Estimated Model

4.1 Affordable housing policy shock

The impulse response of affordable housing policy shock is presented in Figure1. The government expenditure is separated into consumption spending in non-housing sector and production spending for housing sector as input of housing production. Following the affordable housing policy shock, the housing firms can produce more houses for given cost. This leads to an increase in housing supplied (0.1). With higher supply of housing, the housing prices decline immediately after the shock and last more than 20 periods.

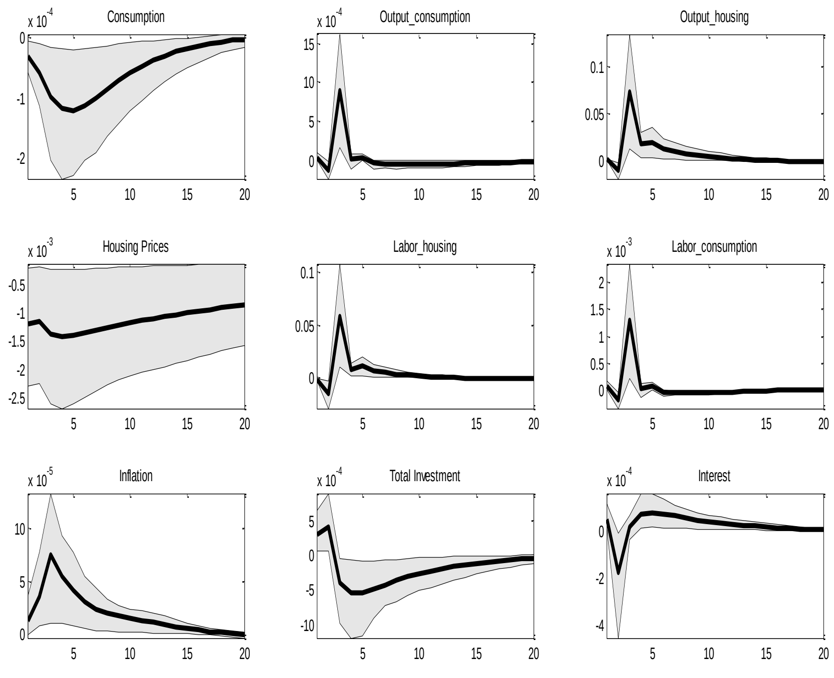

Figure 1 Response to government investment shock

In the consumption goods sector, the reduction of housing prices causes a substitution effect, so households will consume more housing. The consumption firms produce intermediate input for housing sector, thus the consumption production follows the same fluctuation and trend with housing sector on a small scale. Inflation increases because of the deficit spending in housing sector, and the employment in both sectors rises in line with the output respectively.

4.2 New Land policy shock

The effects of a new land policy shock are shown in Figure 2. A negative shock to land cost generates a sharp and persistent growth in housing supply. The housing production rises 0.4 unit in 5 periods and remain significantly above the baseline for about 20 periods. The housing prices reduce slowly, because households cannot immediately match the increase of housing supply. When housing prices drop, households will purchase more housing instead of consuming goods and leisure. Thus, the consumption of households faces a negative effect. Meanwhile, due to the prosperity of real estate market, the housing firms need more housing capital which produced in consumption goods sector to expand production, so the consumption firms face a small positive effect.

The effect of this shock on employment in housing sector and consumption goods sector, total investment and interest are qualitatively similar to those of a positive affordable housing policy shock.

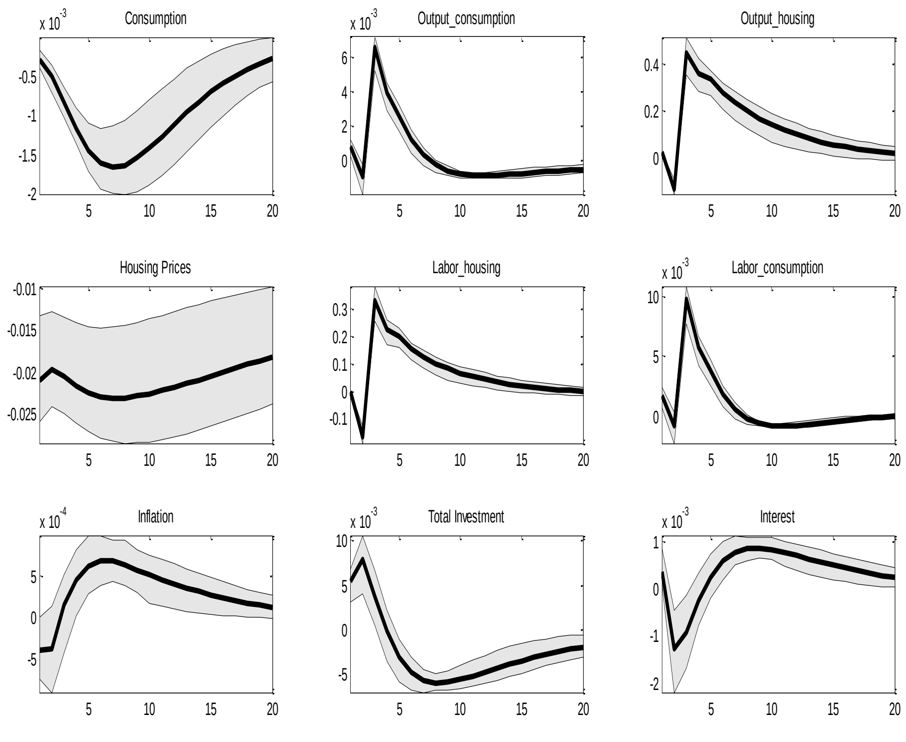

Figure 2 Response to new land policy shock

4.3 Property tax policy shock

Figure 3 shows the effects of a positive property tax shock. After the housing tax shock, households need to spend more money on holding houses, so they will purchase less real estate, thus causing housing demand to decrease. In face of lower housing demand, housing firms respond by reducing real estate production as well as decreasing employment and capital utilization. The decreased housing demand also leads to lower housing prices, as the housing prices drop 0.4 unit immediately and last more than 20 periods. Overall, the housing sector suffers a significant negative effect.

Consumption goods sector is different from housing sector and faces a positive effect. The main reason is that the reduction of purchasing houses leads households to consume more final goods in the consumption sector, and more labor and capital will be supplied to non-housing sector.

As we mentioned, the government expenditure based on the collection of housing tax, so with a high housing tax, the government can spend more on the consumption goods sector, which causes the consumption of household to reduce after 8 periods.

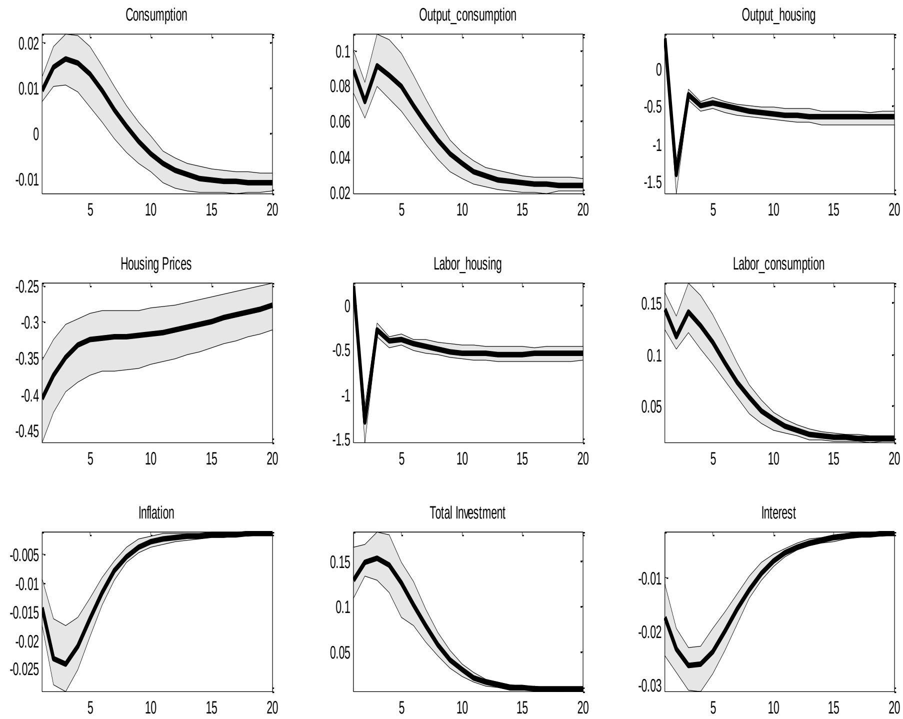

Figure 3 Response to property tax shock

4.4 Monetary policy shock

We consider a monetary policy shock as a change in loan interest rate. A positive shock in loan interest rate generates downward pressure on borrowers' budgets. This leads to a decrease in demand in both sectors.

The effects of this shock on housing production, inflation, and housing prices are qualitatively similar to those of a positive housing tax shock. The main qualitative difference is that both sectors face a negative effect and the impact on non-housing sector is less than on housing sector. The main reason for this situation is that: First, the proportion of borrowers is higher than lenders', which is estimated and shown in the past section. A decrease in demand of borrowers generates a decline in total consumption. Second, borrowers are the main purchasers of housing, which can explain the housing sector is larger impacted by the weak demand of borrowers.

Overall, the property tax policy is better at declining housing prices to a normal level, but it will hit the housing sector. The monetary policy has a similar effect with property tax policy, except the negative effect on consumption goods firms. The new land policy can stabilize the real estate market well, but its effect of controlling housing prices is weak. Compared with land policy, the affordable housing policy has a positive effect on inflation.

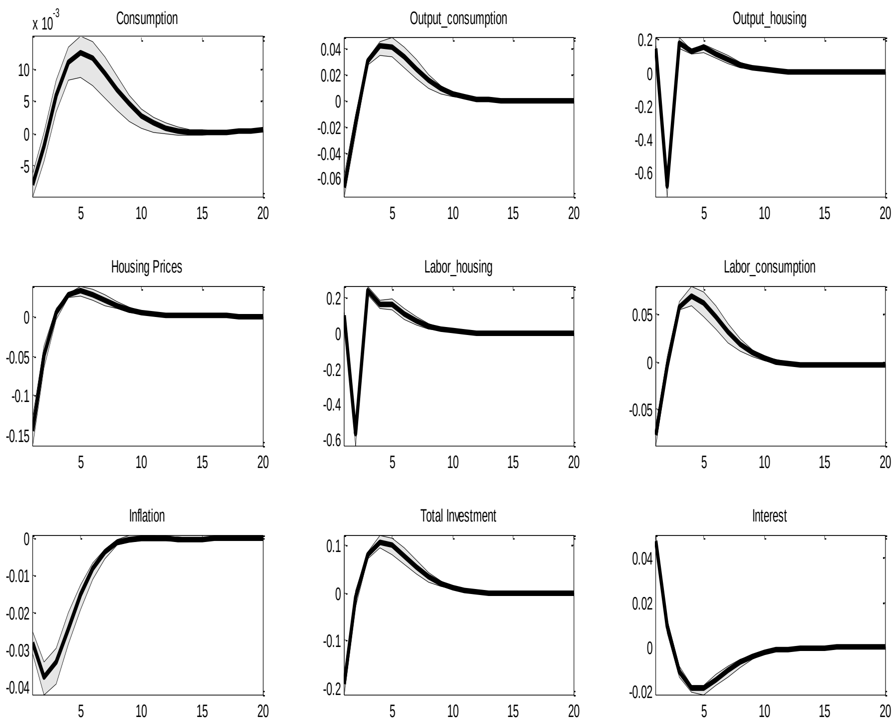

Figure 4 Response to a monetary shock

5. Conclusions

In this paper we have provided a DSGE framework to analyze the effect of the four policies to real estate market. According to the results of the estimated model, we found that:

The property tax policy and monetary policy are good at controlling housing prices, but they will have a negative effect on housing firms. The new land policy and affordable housing policy can promote the development of housing firms, but they are weak at diminishing housing prices.

Compared with monetary policy, housing tax policy has less impact on other sectors and has a more persistent effect. So for the effect of controlling housing prices, the property tax policy is the first option. Meanwhile, the effect of affordable housing policy is analogous to that of new land policy with the exception that it has a positive effect on inflation. So it is better using new land policy to support or stabilize the housing market. Moreover, the result suggests that as a mean to adjust the housing prices, we should focus on the demand part. And if the purpose is to stabilize the housing market, working on supply part is better.

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