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What Drives the House Price Movement? Evidence from Real Business Cycle Analysis

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Abstract

In this paper, we develop and calibrate a general equilibrium real business cycle model with several aggregate shocks to quantitatively study the effects of various shocks on housing price and macroeconomic variables. We found that the TFP shocks play an essential role in the modeled economy - over 98% of the variation of housing price can be explained by the changes in technology in the housing sector. The land price shock accounts for little fluctuations of housing price. This is since the land share in the construction industry is insignificant. The government expenditure shock also has ignorable effect on the housing market. In terms of the impact on aggregate variables, we find that an increase in government spending has positive effects on the overall employment in the short run but no effects in the long run, whereas the improvement of productivity in nondurable sector causes an increase in structural unemployment.

Keywords

Housing Price; RBC Model; Land Price; TFP Shocks; Equilibrium Model.

1. Introduction

In 2008, the subprime credit crisis triggered a severe global recession and drew attention to the health of the housing market. It is widely accepted that housing market dynamics can cause macroeconomic volatility and influence individual saving and consumption decisions, given that a significant portion (over 30%) of people's wealth consists of housing assets. Researchers and policymakers have extensively studied the housing market to answer a crucial question: what causes the housing market to fluctuate, and what are the main factors of housing prices? Previous literature such as Ng (2015) [10], Xu (2013) [12], and Favilukis et al. (2017) [5] has discussed the contributions of housing preference shocks and monetary shocks, mortgage innovation and interest rates, and the relaxation financing constraints on house prices.

The house price, exposed to various aggregate and idiosyncratic shocks, is an efficient indicator of the housing market's status. Therefore, this paper focuses on the effects of fiscal policy shocks, land price shocks, and two types of technology shocks on house prices, employment, and other macroeconomic variables. To analyze these effects, we construct a general equilibrium real business cycle model with two production sectors and incorporate the employment, housing market and consumption market into one framework. Inspired by Favilukis et al. (2017) [5], our model introduces stochastic land prices and government expenditures, allowing us to study the effects of fiscal policy shocks. Additionally, households incur extra costs due to investment-specific friction when changing investments in production capital. In our model, a house is conceptualized as a bundle consisting of structure and land [3]. Thus, the construction of a house not only requires the input of capital and labor, but also land provided by the government. In this case, land, as an input factor in residential construction, plays a critical role in both the housing market and government budget. The supply of land permits is managed by a nonprofit government organization, and government expenditure is primarily financed by the rental rate of permits which are permanent once are issued to construction firms. Figure 1[13] shows the movement of the detrended natural logarithm of land prices and government expenditure between 2002 and 2018. The correlation between these are more clear during the recessions, and the land prices are much more volatile.

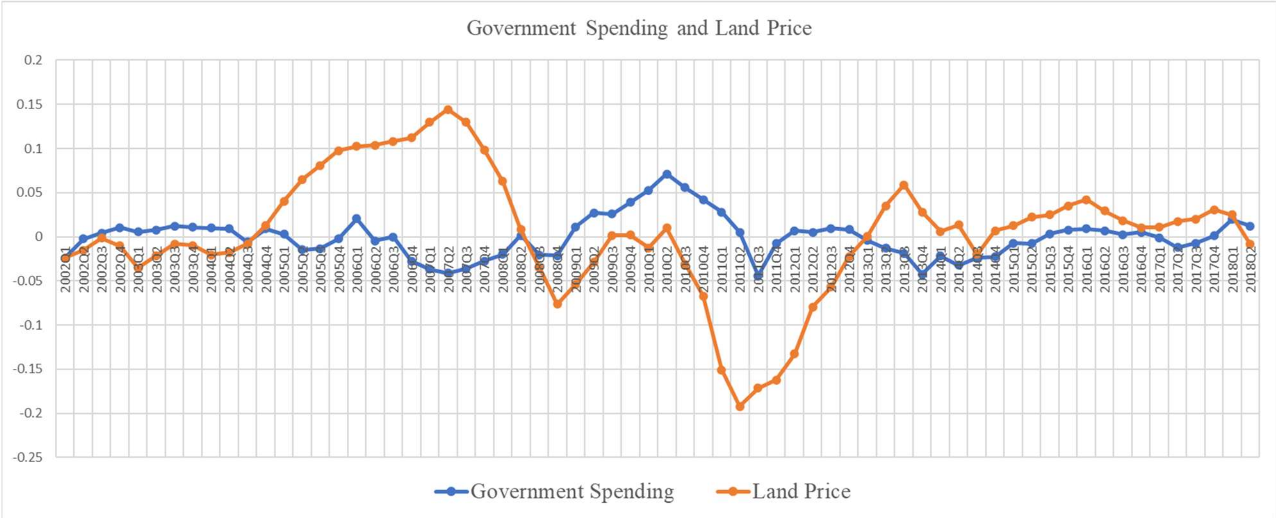

Figure 1. Detrened Land price and government spending

The model in this paper is calibrated to U.S. quarterly data from 1968 to 2018, following traditions in previous literature and empirical analyses. Parameters such as depreciation rate and nondurable consumption weight are averaged over a long-term period. The dynamics of this economy are driven by productivity, government expenditure, and land price shocks. Total factor productivity (TFP) shocks in both production sectors are estimated using Bayesian methods, following Iacoviello and Neri (2010) [7]. Parameters for government policy and land price shocks are calibrated using auto-regression, enabling the model to match realistic statistics.

The main findings of this paper indicate that land prices have a limited effect on house prices, accounting for only 0.07% of house price variations. Rising land prices decrease both demand and supply in the housing market, leading to increased consumption of nondurable goods and higher employment in the consumption sector due to the substitution effect. Fiscal policy has a short-term impact on the macroeconomy, with government spending showing no effect on house prices since the government does not demand housing assets. Fiscal expansion leads to crowding-out effects such as higher interest rates and lower household consumption but creates more jobs and increases overall employment in the short run. Long-term effects eventually fade, returning macroeconomic variables to their initial equilibrium.

Productivity shocks are the primary determinants of economic fluctuations, driving most variations in house prices. The variance decomposition shows that 1.56% and 98% of house price variance are explained by consumption sector technology and housing sector technology, respectively. Consumption sector technology accounts for 80% of nondurable goods consumption movements and 84% of production variations. Additionally, consumption technology shocks can increase structural unemployment in the nondurable goods industry by reducing labor input requirements. In the housing market, housing technology shocks account for 99% of housing demand variance and 95% of residential investment variance.

The relationship between the real estate market and other macroeconomic variables has garnered substantial interest from researchers. Liu et al. (2013) [8] captured the positive co-movements between land prices and business investment by introducing land as a collateral

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asset in firms' credit constraints and incorporating a land price shock into the DSGE model. Davis and Heathcote (2007) [3] discovered that land price, rather than the cost of structures, is the main factor driving house price fluctuations. Aoki et al. (2004) [1] identified the effect of monetary policy shocks on consumption, housing prices, and housing investment. They also found that structural changes in credit markets can amplify the effect on consumption but reduce it on the housing market. Davis and Palumbo (2008) [4] measured the evolution of land values and showed that the land's share in housing value is much greater than it used to be, leading to faster house price growth and increasingly inelastic housing supply.

Favilukis et al. (2017) [5] examined the effect of changes in housing finance on several central endogenous variables. Their general equilibrium model, incorporating aggregate business cycle risk and realistic wealth distribution, demonstrated that a low housing risk premium and relaxed finance constraints resulted in a housing price boom. Houses serving as collateral to borrow against amplifies the effect of monetary policy shocks on housing investment, housing price and consumption [1]. Given the critical role of land price in real estate value, this study models land price as an exogenous variable, while other key variables, such as interest rates and house prices, are endogenous and determined by housing market clearance conditions and the capital market, respectively. Sorge (2023) [11] proposes a simple political economy framework of macroprudential regulation and reveals the mechanism of housing bubbles which result from the lax financial regulation and the positive expectation of housing market. Franjo et al. (2024) [6] apply two-country life-cycle model and solve the puzzle about the different relationships of house prices growth and current account surplus among different countries. Carro (2023) [2] and Mérő et al. (2023) [9] assess the impact of various mortgage risks, construction cost shocks, and family support measures on the housing market through a data-driven agent-based model.

This study significantly advances the understanding of housing price dynamics and macroeconomic fluctuations in the following perspectives. First, it introduces a comprehensive model integrating the housing and nondurable goods sectors, revealing how shocks in one sector affect the other and drive economic cycles. Second, the study emphasizes productivity shocks in the housing sector as primary determinants of economic fluctuations, with over 98% of house price variance attributed to these shocks. This challenges the conventional focus on aggregate demand shocks and suggests targeted policy interventions for sector-specific disturbances. Third, it sheds light on the relationship between fiscal policy and the housing market, showing that government spending shocks minimally impact house prices directly, influencing the market mainly through interest rate changes and crowding-out effects on consumption.

The rest of this paper is organized as follows. The next section presents the structure of the real business cycle model. Section 3 describes the equilibrium conditions. Section 4 presents the results and graphs. Section 5 discusses our findings and simulation results. Section 6 concludes the study.

2. Benchmark Model

In our economy, it is filled with house owners. And a representative household acts as a consumer, worker and producer. An individual can derive utility from nondurable goods, housing services, and leisure. There is no labor market friction, and workers can transfer from one industry to another without any restriction. However, because of investment specific friction, the agent faces investment adjustment cost which is caused by the changes of investment. Household can also invest in financial assets by buying one period risk-free bond issued by the government. Government gathers the tax payment and leases the land permits to construction firms to finance government spending and social benefits. Without losing

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generalization, the government is nonprofit, and after paying the government expenditure, the rest goes back to household as government transfer. Production of nondurable goods requires capital and labor input, and the construction of new houses requires capital, labor and land as inputs.

2.1. The Representative Household

In each period, the event proceeds as follows. At the beginning of each period, the households receive or make interest and principal payment from last period savings or borrowings. Then they supply labor to firms to obtain wage payment, and the government transfers are deposited into their account simultaneously. For retirees, it is also the time when the social benefit is paid. At the end of each period, agents decide whether to move to a new place. If they do, they will sell their old house and purchase a new one for the next period housing consumption at current house price. Then the expenditure on nondurable consumption is made. Now given the income and housing decision, agents decide how much to save or borrow in financial assets.

We can write down the household's utility function as follows:

$$u(c_t, h_t, n_t) = \gamma \frac{c_t^{1-\eta}}{1-\eta} + (1-\gamma)\frac{h_t^{1-\theta}}{1-\theta} + \xi \ln(1-n_t) \tag{1}$$

Each household is endowed with one unit of time and $n_t \in [0,1]$ refers to the time fraction on working. Parameter γ is the weight on consumption, η and θ are non-durable good and housing consumption elasticities.

Households supply labor and earn wage income. We assume everyone is a house owner. At the end of each period, they sell their current house, h_t and purchase a new one, h_{t+1} for next period, where h_t stands for the amount of housing units such as square feet owned by household at time t. Then the household's problem can be written as:

$$\max_{\{c_t, n_t, h_{t+1}, I_t, k_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\gamma \frac{c_t^{1-\eta}}{1-\eta} + (1-\gamma)\frac{h_t^{1-\theta}}{1-\theta} + \xi \ln(1-n_t)\right)$$

Subject to:

$$c_t + I_t + (B_{t+1} - B_t) + \delta_h P_t^h h_t + (h_{t+1} - h_t)P_t^h \leq B_t i_t + w_t n_t (1-\tau) + r_t^k k_t + tr_t \tag{2}$$

$$k_{t+1} = \left(1 - \frac{\psi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) I_t + (1-\delta)k_t \tag{3}$$

$$c_t, h_t, n_t \geq 0 \tag{4}$$

Equation (2) is the budget constraint for a household. In each period, household makes investment I_t into the business and buys one period risk-free bond B_{t+1} at real interest rate i_t as a financial asset. Household makes decisions on consumption amount c_t, hours to work n_t, and next period housing service h_{t+1} to maximize the utility. Other income sources include the rental of capital r_t^k and government transfers tr_t. Equation (2) is the capital evolution path. Capital depreciates at rate δ and ψ is the investment adjustment cost parameter. When $\psi = 1$, then the adjustment cost equals 0. Equation (3) gives us the non-negative constraint.

ISSN: 2692-7608 DOI: 10.6981/FEM.202407_5(7).0017

2.2. Production Sectors

The production sectors have similar assumptions as Favilukis et al. (2017) [5]. We have two production sectors: one produces nondurable consumption goods, and another produces durable goods such as housing services. For the rest of this paper, we refer to the first one as consumption sector, and the second one as housing sector. Each firm can take its required capital from the capital stock. Labor flow is totally free. Both firms pay the same rate of return of capital and the same salary. Both markets are perfectly competitive, and equilibrium prices are only determined by supply and demand.

For nondurable goods sector, the production function is given by:

$$Y_t^c = Z_t^c (K_t^c)^{\alpha} (N_t^c)^{1-\alpha} \tag{5}$$

The production of consumption output Y_t^c requires K_t^c that denotes the capital inputs and N_t^c which refers to the labor input in aggregate level. Where Z_t^c is the technology productivity in consumption sector, and follows the stochastic process:

$$\ln Z_t^c = \rho_c \ln Z_{t-1}^c + \epsilon_t^c, \quad \epsilon_t^c \sim i.i.d.(0, \sigma_c^2) \tag{6}$$

Where ρ_c measures the degrees of persistence, and ϵ_t^c is a stochastic independent distributed shock to productivity.

For the housing service sector, besides the capital and labor, the producer also takes land as a production factor. Denote output in the residential housing sector as:

$$Y_t^h = Z_t^h (L_t)^{1-\phi} \left[\left(K_t^h\right)^{\nu} \left(N_t^h\right)^{1-\nu} \right]^{\phi} \tag{7}$$

Parameter ϕ and ν stand for land share and capital share in housing production, respectively. And L_t refers to land input, K_t^h and N_t^h refer to capital input and labor input. Analogous to nondurable sector, the aggregate productivity level Z_t^h is stochastic and follow AR (1) process:

$$\ln Z_t^h = \rho_h \ln Z_{t-1}^h + \epsilon_t^h, \quad \epsilon_t^h \sim i.i.d.(0, \sigma_h^2) \tag{8}$$

The persistence of shock is denoted by $\rho_h \in (-1,1)$, and σ_t^h is the standard deviation of the innovation.

Capitals are constrained by total capital stock:

$$K_t^c + K_t^h = K_t \tag{9}$$

Where K_t is the aggregate capital stock invested by the household in the economy.

2.3. Government

Government in our economy collects income tax $(w_t \tau)$, pays social benefit (tr_t) and issues government bond (B_{t+1}). Bond purchased by households. Land per capita l_t, in the form of permits is only provided by the government. The budget constraint of government is:

$$g_t + i_t B_t + tr_t = p_t^l l_t + w_t \tau + (B_{t+1} - B_t) \tag{10}$$

ISSN: 2692-7608 DOI: 10.6981/FEM.202407_5(7).0017

Where p^l is the land price which is not set by the government. The sale of the land is used to finance government spending g_t. To study the effect of price of land on housing price, we assume the land price is stochastic and follows AR (1) process.

$$\ln p_t^l = \rho_l \ln p_{t-1}^l + \epsilon_t^l,\;\; \epsilon_t^l \sim i.i.d.(0, \sigma_l^2) \tag{11}$$

And government spending is interpreted as an expenditure shock that reflects some unexpected events the require unplanned extra spending. The shock process follows:

$$\ln g_t = \rho_g \ln g_{t-1} + \left(1-\rho_g\right) \ln \bar{g} + \epsilon_t^g \tag{12}$$

Where $\bar{g}$ is steady-state value of government spending.

3. Equilibrium Conditions

The equilibrium is defined as follows: the markets for goods, housing, and labor are all clear. And the equilibrium consists of sequences of prices $\{w_t, P_t^h, i_t\}_{t=0}^{\infty}$ and all macroeconomic variables $\{K_t, N_t, C_t, H_t, L_t\}$ such that all the optimizing problems for household and firms are solved, and all markets clear.

Euler Equation:

$$E_t \left(\frac{c_{t+1}}{c_t}\right)^{-\eta} = (1 + i_{t+1})\beta \tag{13}$$

First order condition w.r.t consumption:

$$\lambda_t = \gamma c_t^{-\eta} \tag{14}$$

The λ_t denotes the Lagrangian multiplier for the budget constraint.

First order condition w.r.t labor:

$$\frac{\xi}{1-n_t} = \lambda_t w_t (1-\tau) \tag{15}$$

First order condition w.r.t h_{t+1}:

$$\beta(1-\gamma) h_{t+1}^{-\theta} + \beta E_t \left(\lambda_{t+1}\left(P_{t+1}^h - \delta_h P_{t+1}^h\right)\right) = \lambda_t P_t^h \tag{16}$$

First order condition w.r.t k_{t+1}:

$$\mu_t + \beta E_t\left(\lambda_{t+1} r_{t+1}^k\right) = \beta(1-\delta) E_t(\mu_{t+1}) \tag{17}$$

The μ_{t+1} subscripts the Lagrangian multiplier for the capital evolution equation.

Investment I_{t+1}:

ISSN: 2692-7608 DOI: 10.6981/FEM.202407_5(7).0017

$$\mu_t\left[\frac{\psi}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2+\psi\left(\frac{I_t}{I_{t-1}}-1\right)\frac{I_t}{I_{t-1}}-1\right]+\beta E_t(\mu_{t+1})\psi\left(\frac{I_{t+1}}{I_t}-1\right)\left(\frac{I_{t+1}}{I_t}\right)^2=\lambda_t \quad (18)$$

Without the investment friction, $\psi=0$, we can get $\mu_t=-\lambda_t$.
Good market clear:

$$y_t^c=c_t+I_t+g_t \quad (19)$$

Where I_t stands for investment per capita. The investment goods are produced by the nondurable good production sector.
Labor market clear:

$$n_t=n_t^c+n_t^h \quad (20)$$

The subscriptions n_t, n_t^c, n_t^h are total working hours, working hours in consumption sector, and working hours in housing sector per capita, respectively.
Housing market clear:

$$h_{t+1}=(1-\delta_h)h_t+y_t^h \quad (21)$$

In equilibrium, the housing stock will hold constant over time, and the new residential investment will equal to the housing depreciation.
Government budget constraint:

$$g_t+i_tB_t+tr_t=p_t^l l_t+w_t\tau+(B_{t+1}-B_t) \quad (22)$$

The equilibrium values of allocations $\{c_t, h_t, i_t, n_t, k_t, y_t, p_t^h\}$ are attached in Appendix.

4. Calibration and Estimation

In this section, we describe our calibration procedure of the benchmark model. In total, the model has eleven parameters, and they are calibrated either based on the traditions in previous literature or the U.S data set. Table 1 represents the model's parameters and their numerical calibration.

This paper sets the elasticity of consumption of two types of good equal to 1 to suggest a unit elasticity. The utility function becomes $u(c_t,h_t,n_t)=\gamma\ln(c_t)+(1-\gamma)\ln(h_t)+\xi\ln(1-n_t)$. The weight on nondurable good γ is set equal to 0.85 to match the fact that the share of durable good and housing service out of total personal expenditures is close to 0.15 between 2000 and 2018. The measure of leisure and working hours is from the American Time Use Survey (ATUS). The constraint on time which is $n_t+l_t=1$, indicates that the activities other than working and leisure do not provide utilities. The average hours engaged in working and working-related activities is 4.61 and in leisure is 4.72 hours per day. Therefore, the weight on leisure ξ is set equal to the ratio which is 0.5059. The discount factor β is set to 0.99 which implies the quarterly long-term interest rate equal to 0.722%.

The depreciation rate of capital is calibrated to match the depreciation-capital ratio. The fixed assets data and depreciation can be found on the Bureau of Economic Analysis Real Depreciation table. Private nonresidential fixed assets contain two types of capital: equipment

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and structures. They depreciate at two different rates; the average deprecation rate for equipment is 0.13 and for structures is 0.03. Therefore, the average annual depreciation rate of capital, δ is set to 0.081. The new house depreciation rate is calibrated through depreciation-to-residential investment ratio. The annual δ_h is set equal to 0.023 which is the average annual rate between 1999 and 2018.

The tax rate τ is calibrated to match the individual effective marginal tax rate on wages, salaries, and capital income, 2019. The tax table this paper refers to is from Tax Policy Center (TPC), which is a nonpartisan, independent organization. The effective marginal tax rates are weighted by the appropriate income source and calculated by adding $1,000 to the income source and dividing the resulting tax change by that $1,000. In all, the individual income tax rate including payroll tax is 0.319.

The paper calibrates the capital share α in nondurable good production function which takes the form of Cobb-Douglas function $Y_t^c = (K_t^c)^\alpha (Z_t^c N_t^c)^{1-\alpha}$ to match the U.S. data. The average capital-income share, α, is set equal to 0.35 between 1954 to 2018. The land share $(1-\phi)$ in construction industry is 10% to match the average land-residential ratio. The capital share $\nu = 0.3$ is following Favilukis et al. (2017) [5] where the capital share is set to match the evidence used in Davis and Heathcote (2007) [3]. The capital adjustment cost ψ is set to be 4 which is commonly used in current macroeconomic literatures.

Table 1. Parameter Values

Constraint	Description	Value
Preferences		
η	Nondurable good elasticity	1
θ	Durable good elasticity	1
γ	weight of nondurable goods	0.85
ξ	weight of leisure	0.5059
β	Discount factor	0.99
Production		
α	Capital share in consumption sector	0.35
ϕ	Non-land share in housing sector	0.9
ν	Capital share in housing sector	0.3
δ	Capital depreciation rate	0.02025
δ_h	Housing depreciation rate	0.00575
ψ	Investment specific adjustment cost	4
Government		
τ	Personal income tax rate	31.9%
Shocks		
ρ_c	Technology in nondurable	0.95
ρ_h	Technology in construction	0.997
ρ_l	Persistence in land price	0.905
ρ_g	Persistence in government spending	0.757
σ_c	Standard deviation on consumption	0.01
σ_h	Shock of construction	0.0193
σ_l	Shock of land price	0.0221
σ_g	Shock of government spending	0.0146

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Both TFP shocks, Z_c and Z_h follow AR (1) process. The coefficients of the auto-regressive ρ_c and ρ_h are set to be 0.95 and 0.997 respectively and are consistent with the Iacoviello and Neri (2010). They estimate their model from 1965: Q1 to 2006: Q4 through a Bayesian approach. The rate of technological process in the consumption sector is faster than that in the housing sector. The auto-regressive coefficient of government policy shock is calibrated by using U.S data between 2002: Q1 and 2019: Q3. Coefficient ρ_g and the standard deviation σ_g are set to be 0.757 and 0.0146 respectively. Land price series is constructed based on Federal Housing Finance Agency (FHFA) land price index from 1975: Q1 to 2018: Q2. For the land price shock, we approximate the continuous AR (1) process, and the coefficient ρ_l is set to equal 0.905 and the standard deviation σ_l is set to 0.0221.

5. Economic Implications

In this section, this paper represents the model's main findings, results and the average equilibrium allocations over a simulated sample path, and their implications based on the calibrated parameters. We also examine the effects of different shocks on macroeconomics variables. And we find that the land price does not contribute to the growth of house prices as much as we expected. The determinant of house prices is the technology productivity in the construction sector.

5.1. Sources of Fluctuations in the Market

The table below (Table 2) represents the quarterly equilibrium values and properties of our essential macroeconomic variables. The house price is a relative price which is in terms of nondurable consumption price.

Table 2. Benchmark Simulation

Variables	Description	Steady-State	Std. deviation	Correlation with GDP
c^*	Consumption	1.321	0.0442	0.7681
h^*	Housing service	9.013	3.1445	0.1856
y_h^*	House production	0.052	0.0442	0.2939
y_c^*	Non-house production	1.874	0.0664	0.7965
n_c^*	Labor in consumption	0.502	0.0063	-0.2671
n_h^*	Labor in construction	0.023	0.0114	0.3906
r^*	Interest rate	0.010	0.0014	-0.5524
p_h^*	House price	1.631	0.3417	-0.2593
tr^*	Government transfer	0.314	0.0175	0.9676
GDP	GDP	1.958	0.0732	1

GDP is calculated as a sum of non-housing production and market value of housing production. The math expression of GDP is $GDP = y_h * p_h + y_c$. From the table above, we can know that nondurable consumption is much less volatile than housing consumption. Given the technology level, the equilibrium relative house price is 1.631. And the real business cycle model delivers us a negative correlation between the house price and GDP. This implies that as the economy grows, the real relative house price decreases. House prices and interest rates are weakly countercyclical. For production sectors, both nondurable good production and durable good production have positive correlations with GDP. Higher weight of consumption sector in GDP increases the correlation. In the labor market, there is a noteworthy point, the model gives us a negative relationship between GDP and consumption sector employment. The reason is that an

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increase in nondurable sector employment will cause the overall employment to fall given the correlation between n_c and n_t is -0.76, and in this case, the GDP decreases.

Table 3. The ratios of macro-variables to GDP

Variables	Description	Steady-State
c^*/GDP	Consumption share of GDP	0.6744
y_c/GDP	Consumption sector share of GDP	0.9567
$y\_h * p_h/GDP$	Residential investment share of GDP	0.0433
$k_c/(y_c * 4)$	Nondurable capital-output ratio	2.8817
$k_h/(y_h * 4)$	Housing capital-output ratio	3.6154
$K/(GDP * 4)$	Capital-GDP ratio	2.8529
n_c/n	Nondurable labor share	0.9579
I/GDP	Business investment share	0.2311

Table 3 illustrates the essential ratio values of the economy. The household's consumption contributes 67% of GDP. On production sector, nondurable good production and the residential investment take 95.7% and 4.3% of GDP, respectively. Since capital goods are durable goods and results are based on quarters, the output is multiplied by 4 when calculated capital-output ratio since the simulated GDP is generated quarterly. The capital-GDP ratio is 2.85 and it is close to 2.8 which is the average tangible capital-output ratio between 1929 and 2013. In the construction industry, the ratio is higher than in the consumption sector. Around 95% of total labor work is in nondurable goods sector, consistent with the labor facts from Bureau of Labor Statistics (BLS).

Table 4. Decomposition of Variances of Selected Variables

Variables	z_c	z_h	p_l	g	Total
c	80.11%	19.17%	0.71%	0.01%	100%
h	0.19%	99.72%	0.10%	0	100%
y_h	2.42%	95.71%	1.80%	0.08%	100%
y_c	84.41%	15.02%	0.49%	0.07%	100%
n_c	26.89%	68.91%	3.41%	0.79%	100%
n_h	6.02%	89.34%	4.43%	0.21%	100%
r	62.70%	27.11%	10.17%	0.01%	100%
p_h	1.51%	98.42%	0.07%	0	100%
tr	79.81%	17.21%	1.18%	1.81%	100%

Table 4 illustrates the relative importance of the shocks on driving fluctuations of the house price and other key variables. The way we do this is to examine the variance decomposition. The first two columns show the effects of TFP shocks, and the last two columns show the effects of land price and government spending shocks, respectively. In our real business cycle model, both consumption sector technology shock and construction technology shock account for a substantial part of the volatility of variables compared to the other two shocks. Nondurable good consumption is highly affected by the TFP shocks. In our model, the weight of nondurable good consumption in household's utility is 0.85. When productivity increases, decreasing price drives the demand to grow rapidly. And because of this low weight of housing service, the technology in construction industry only accounts for 19.17% of changes in consumption, while consumption technology shock accounts for 80%. The government has no demand for housing

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service and government spending shock contributes to around 0.01% to the fluctuation of consumption.

The housing demand, on the other hand, 0.19% variance is constituted by nondurable goods sector shock and construction shock contributes over 98% of the fluctuation in housing price, which is different to Liu et al. (2013) [8]. When the house price decreases because of the increasing supply, households cut the consumption of nondurable goods and switch to housing service to increase their utility. On account of the different weights on housing and consumption, this increase in housing demand is not as much as the increase in consumption caused by consumption technology. Land prices and government shocks barely affect the demand for durable goods. The labor demand is highly sensitive to productivity shocks and 89% of labor demand variance in housing sector is explained by the housing TFP movement. Growing technology will cause an increase in structural unemployment.

Government expenditure shock explains more than 0.79% of the variance of employment in consumption sector. While in the housing sector, this percentage drops to 0.21%. The net effect of government spending on employment is non-zero. The growth in government spending increases the overall demand of nondurable goods and then drives the supply to grow. Expansionary fiscal policy has a positive effect on production and employment. The fiscal policy shows no effect on house prices since the government is not involved in the housing market.

The land price only accounts for a small part of the volatility of house price in our model. A possible reason is that the weight of land as an input in housing production is only 10%. In addition, the land price has no direct impact on consumption and production of nondurable goods. Higher land price causes the house price to increase, and because of substitution effect, the consumption of nondurable goods increases. There is one thing to notice is that the land price contributes a 10% variance of interest rate.

To summarize, technology productivity plays an essential role in the economy. The large part of variance of house prices is explained by movement of the supply, which is affected by the TFPs. The fiscal policy shows positive effect on employment, but the side effect is crowd-out effect with higher interest rate. The impact of land price is limited and can only describe a small part of economic fluctuation.

5.2. Impulse Responses

In this section, the paper illustrates the impulse responses of real business cycle variables to land price shock, government expenditure shock, and TFP shocks, respectively.

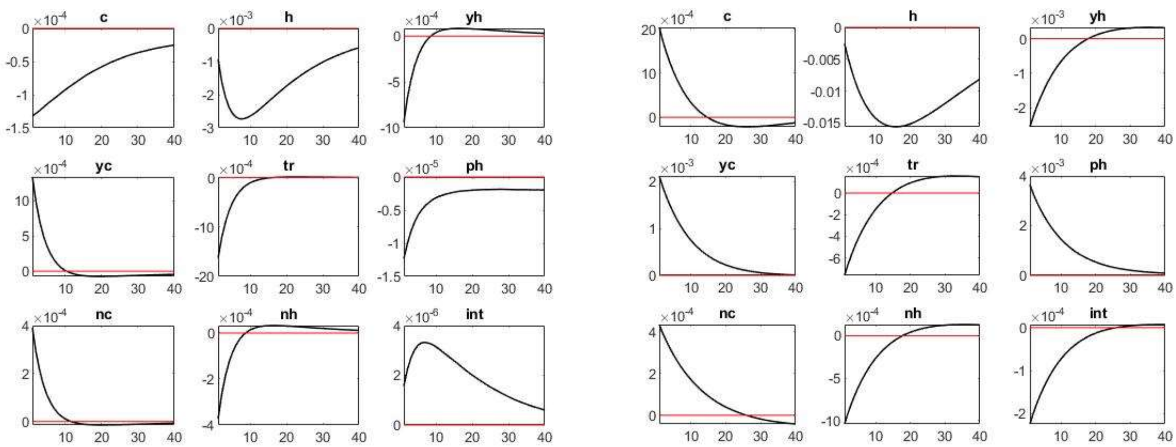

Figure 2. Impulse responses of macro-variables to governement spending shock (left side) and land price shock (right side)

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Figure 2 represents the impulse responses to government spending (left side) and land price (right side), respectively. When the government increases its expenditure to react to unexpected events, both individuals' housing and non-housing consumption drop. And clearly, we also have crowd-out effect, the rising public spending drives the private spending to decrease. Encountering the decrease in demand for housing service, the construction firms lay off workers to cut their house supply to maintain the equilibrium house price. Therefore, the house price is barely affected by the government spending. Increase in government expenditure drives the non-housing goods production to increase, and this growth in supply requires more labor, and the overall employment n_t increases. The fiscal policy has a positive effect on job creations. In short run, the interest rate increases rapidly but in the long run, the interest rate is dragged back to the initial equilibrium value. Sudden increase in government spending also hurts government transfers. In short, the expansionary fiscal policy can only cause a short-term fluctuation in economies and have little effect on the long run.

Land, as a production input, is provided unlimitedly by the government, and the change in price of land can affect government revenue as well as construction cost. When the land price increases, the marginal cost of building a house increase. This decrease in house supply leads the house price to increase. The demand for housing services will fall which causes the construction firms to lay off workers. People who lose their jobs in the construction industry transfer to the consumption sector. Facing higher housing prices, individuals take nondurable goods as substitutes to maintain their utility. Higher land prices can raise the government revenue to increase due to a part of revenue coming from the land sale. And government expenditure rises as well. The aggregate demand for nondurable goods shifts to a higher level. Another source of government income is from the sale of risk-free bonds. When the higher land price brings in higher revenue, the government is less likely to issue bonds to finance its expenditure. In this situation, the supply of the bond decreases and the interest rate is going to decrease. The increasing land price imposes a negative effect on government transfer.

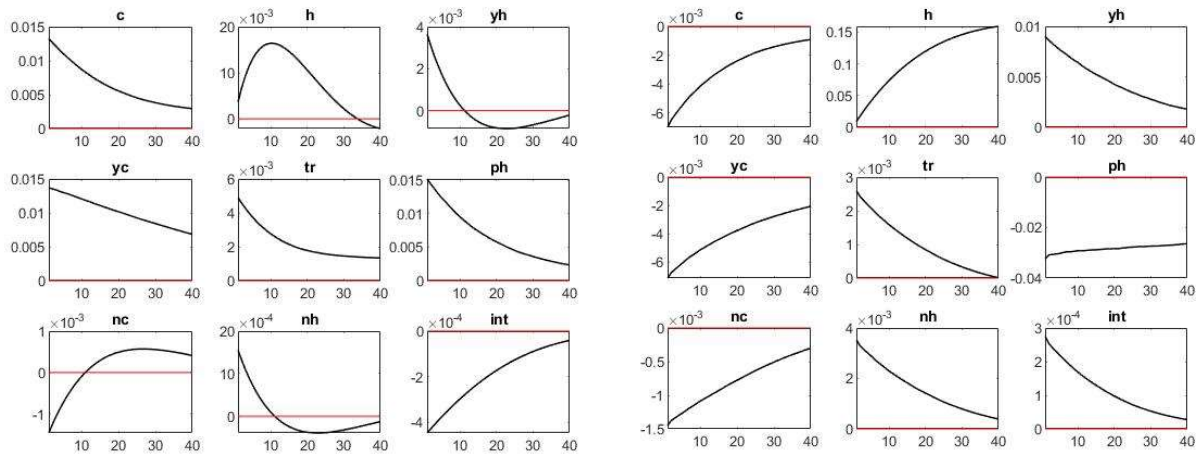

Figure 3. Impulse responses of macro-variables to TFP in the consumption sector (left) and land TFP in the housing sector (right)

Figure 3 represents the impulse response to TFP shocks of the consumption sector (left side) and the housing sector (right side). A positive shock technology growth leads both consumption and production of nondurable goods to increase. An increase in productivity in the consumption sector drives the marginal cost to decrease. Therefore, the relative house price increases. Demand for housing service increases which implies the house price also declines but less than the price of nondurable goods. The durable goods consumption goes up and ends

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up above the original equilibrium point. The demand for labor falls. One possible explanation is that the technology explosion in consumption sector boosts the productivity, and fewer labors are needed in this sector to maintain the production. The construction industry is also affected. Since workers in consumption sector are fired and then they switch to construction industry. More houses are built because of this increase in labor input. The house price decreases, and the relative house price increases due to the huge drop in consumption price. But in the long run, employment in durable goods sector increases and converges back to original point. The overall GDP is both dragged to a higher level. Thus, we can say that technology plays a critical role in macroeconomy. But overall employment has dropped. Because an increase in technology boosts the productivity per laborer, the demand does not increase as much at the same time. In this case, advanced technology leads to higher structural unemployment. Government transfers in our model are the rest of government revenue after it pays its debt and its own expenditures. No doubt households are better off during the economic boom. Residential investment increases in the long run as well. The labor in this sector converges to the initial level, which implies this growth might be caused by the changes in capital since the interest rate decreases.

Figure 3 (right side) shows the impulse response to construction technology. With technology growth, the productivity in construction industry increases and the relative house price decreases. Lower house price stimuluses the housing service demand. According to our assumption, the government has no demand for housing service. Therefore, the increases in housing construction are all consumed by the households. The house production also requires land as a production factor. The growing land sale leads government revenue to increase, in which case, the government transfers increase as well. Due to the substitution effect, the demand for nondurable goods drops. The labor transfers to construction industry. Opposite to the growing unemployment caused by rising nondurable productivity, the overall employment increases when the TFP in the housing sector increases. The reason is that the increase in output caused by improvement in productivity still cannot satisfy the growing demand. Therefore, the construction firms need to employ more laborers. But in the long run, overall employment moves back to the initial equilibrium point. Because of the decrease in labor input in the consumption sector, the nondurable goods production falls. The decrease in the interest rate can be explained by the decrease in demand for bonds. Although housing assets and financial assets are two different forms of individual wealth, they do share some features. When households purchase bigger houses, they cash in their bonds. The bond price falls, and the interest rate increases.

6. Conclusion

In this paper, we examine the effects of total factor productivity (TFP) shocks, land price shocks, and government expenditure shocks on macroeconomic variables such as employment and house prices using a general equilibrium real business cycle (RBC) model with two separate markets. In equilibrium, both the nondurable goods market and the housing market clear. This study addresses the factors contributing to house price fluctuations and investigates the impact of fiscal policy on employment.

In our model, land functions solely as a construction input and cannot be used as collateral. It is not considered a durable capital good and can only be supplied by the government. Due to the low weight of land in construction, land price fluctuations account for a small fraction of house price variations. High land prices reduce housing demand, and due to the substitution effect, nondurable goods consumption rises. Government spending shocks have minimal impact on house prices since the government does not demand housing assets. Fiscal policy has no direct effect on the housing market. Increased government expenditure results in crowding-

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out effects such as higher interest rates and lower household consumption. In the short term, expansionary fiscal policy positively affects overall employment and creates more jobs. However, in the long run, these effects fade, and macroeconomic variables return to their initial equilibrium.

In our model, productivity shocks are the primary determinants of economic fluctuations. Over 98% of house price variance can be explained by shocks in the housing sector. Additionally, housing sector shocks account for nearly 99% of housing demand fluctuations and 95% of residential investment variance. In the nondurable production sector, productivity shocks account for 80% of consumption fluctuations and 84% of production changes. Furthermore, consumption technology shocks can lead to higher structural unemployment in the nondurable goods industry as productivity improvements reduce labor requirements.

This paper acknowledges several limitations that could inspire future research. First, the model underestimates the importance of land. The assumption that unlimited land cannot be owned by households and is not a collateral asset may be overly simplistic. Extending the model to allow households to use their homes as collateral could reveal how credit constraints affect house prices. Second, the model restricts households from accessing risky financial assets such as stocks, limiting them to bonds. Including risky assets could provide insights into household wealth allocation and its implications for savings and consumption. Lastly, while this study focuses on fiscal policy, monetary policy also significantly impacts real estate valuation. Incorporating interest rate effects into a DSGE model with monetary policy could further elucidate this relationship.

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