House Price Mechanism: Focus on the Effect of macro-prudential, monetary, and fiscal Policy

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The effect of monetary policy on the Korean housing market magnifies in the economic structure with the higher LTV ratio. A 25bp rise in interest rates causes a fall in consumption by 0.369%. And, the falling consumption in response to the impact of interest rate rise has a house price mechanism operating under it and house mortgage loan placed at its center. The rise in interest rates affects house prices to decelerate and dwindles the size of credit through the mortgage market, thereby increasing the influence of nominal interest rate. As the LTV ratio is raised higher—meaning less regulation, the rise in interest rates causes a larger contraction in aggregate production. To put it another way, monetary policy could serve a significant role in reducing the volatility of the housing market with concurrent impacts on overall business conditions, so decisions on the policy should be made with a caution.

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Keywords: DSGE model, monetary, macro-prudential, and fiscal policy, LTV (Loan-to Value)

I. Introduction

The global financial crisis in recent years is an evident case that the boom and bust cycle in the housing market causes enormous impacts on the overall economy. In the boom cycle, the market experiences a rise in asset prices and subsequent increase in collateral values, which leads to a higher leverage of households and corporations, meaning the increase in debts of households and corporations. On the other hand, in the bust cycle, the market witnesses a fall in collateral values and credits, which affect financial soundness of lenders, thereby accelerating the pace of de-leveraging. In this process, the stability of financial market could be severely damaged, eventually posing a threat to the soundness of overall macroeconomic conditions. The housing financial market tied to real estates is now at the center of all the attention since the crisis triggered by the sub-prime mortgage. This is because a consensus has emerged concerning that impacts of financial market instability with real estate recession have caused much worse consequences on the real economy than other economic difficulties have brought (Reinhart and Rogoff, 2009). In Korea, this recognition is reflected in the 8th revision of the "Bank of Korea (BOK) Act" on 16th September, 2011. Its provision specifying BOK's purpose was added by the phrase, "the BOK shall pay attention to financial stability in carrying out its monetary policy."

This implies that the central bank takes 'financial stability' as its new policy goal. In this sense, stabilizing the housing market could be an important issue given its huge impacts on the financial market structure.

Navigating through the sub-prime mortgage crisis, the US, in its efforts to restore the stability of the housing market, has decreased its nominal interest rate to almost zero and implemented quantitative easing measures so as to ease the credit crunch in the financial market. At the same time, it has also initiated LTV regulations as a policy tool for macroeconomic prudence to prepare for later challenges or crisis in the housing market.

In April, 2013, Korea's policy authority announced a series of policies on macroeconomic and fiscal prudence with its focus on the housing financial market stability. They include easing LTV regulations for first-time home buyers and exempting acquisition tax for house purchase, though temporarily. Soon, the BOK cut the nominal interest rate and implemented expansionary monetary policy. Now, it becomes highly important to analyze the effects of monetary, fiscal and macro-prudential policies—designed to stabilize the housing market—in the comprehensive manner.

This paper used simulations from a DSGE model to analyze the effects of monetary, macroeconomic prudence and fiscal policies on the stability of the housing market with its main focus on the volatility in the housing market. In fact, Korea's housing market has not comprehensively been studied so far. It was targeting the followings, respectively: monetary policy and consumption, monetary policy and GDP, and macroeconomic prudence policy and macroeconomic variables. Based on the recognition, this paper took a step forward to deal with the three policy variables within the DSGE model in the comprehensive manner, and adding to that it explored effects of fiscal policies.

Section II includes the reviews of preceding studies. Section III examines the impacts of the boom and bust in the housing market on the cycle and volatility of economic indicators related to the housing market. Section IV outlines the impacts of respective policies on the housing market volatility based on a basic numerical model. Section V canvasses respective policy effects with the consideration of the interconnection between economic agents through the DSGE model, followed by Section VI and VII concluding overall outcomes and delivering underlying policy implications.

II. Literature Review

Huidon Kang (2006) argued that austerity policy would pull down house prices. A fall in house prices is brought by income effect-meaning shrinking demand caused by falling income—and by substitution effect-meaning increasing demand on alternative assets. According to Kang, for this reason, the central bank should also take the housing market stability into consideration when deciding on the interest rate level. In the meantime, his analysis of impacts of the LTV ratio change—as one of policy tools for macroeconomic prudence—on household consumption revealed that the lower the ratio is, the weaker the consumption of

households becomes due to tightening policy.

Hyun-Euy Kim and Jun Myung Woo (2006) explained the effects of monetary policy according to changes in borrowing conditions by showing the simulation results that as the LTV ratio rises and therefore borrowing conditions improve further, impacts caused by changes in the policy interest rate heightens the volatility of consumption. In other words, according to the simulation, when the LTV ratio rises from 50% to 60%, aggregate consumption increases 10bp from 0.225% to 0.235%. In addition, when the economy keeps the LTV ratio at 50% and the call rate is cut by 25 bp, aggregate consumption rises by 0.35%.

Kyu Il Chung (2007), while analyzing the effects of monetary policy on private consumption, concluded that an interest rate rise of 25bp would result in the fall in aggregate consumption by 0.32% in the first quarter. In addition, when the central bank takes active actions in response to inflation, the volatility of macroeconomic variables could be controlled effectively. Therefore, Chung strongly emphasized that the central bank should respond more actively to inflation than to economic fluctuation.

The above paper, however, did not take a comprehensive perspective experiment in their comparison of effects of monetary, macro-prudential and fiscal policies in the view of house price mechanism. On the other hand, Crowe *et. al* (2011) pointed that monetary policy targeting the housing market stability would require a huge social cost. A tightening policy designed to avoid overheating of the housing market would push up loan interest rate, which would in turn decrease the demand for house mortgage. Here, the declined demand might work to alleviate risks in the housing market by shrinking leverages of the financial sector, but this could bring adverse impacts on output gap and employment rate, causing huge burdens on the economy as a whole. But this paper also did not present the house price mechanism in the context of general equilibrium economic structure.

III. Stylized Facts about Housing Market Variables

1. Outlines of Korea's Monetary, Macro-prudential and Fiscal Policies Since 2000

Korea's policy for housing market stability was focused on mainly eliminating speculative investment, and hence several fiscal policies, including heightening housing capital gain tax and acquisition and registration taxes, have been used since the 1970s. It was after 2000 that with the mortgage market emerging, regulations on loan conditions like LTV(Loan to Value Ratio) and DTI were used to stabilize the housing market.

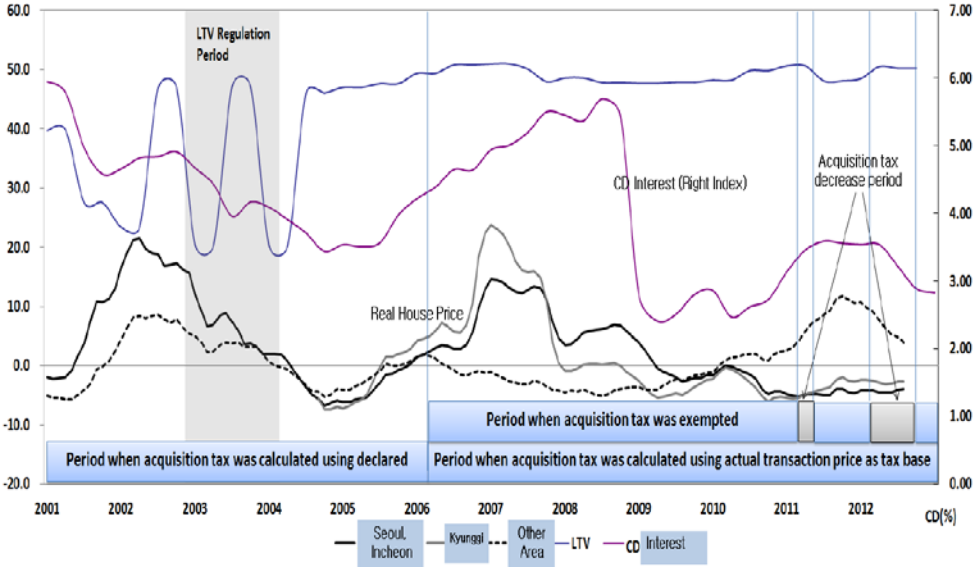
Figure 1 shows that the reduction in acquisition and registration taxes in 2006 was more close to lessening actual tax burdens as the authority began to use actual transaction price as tax base. The reduction stayed for straight 52 months—from Sep. 2006 to Dec. 2010—and was temporarily lowered to 1~2% from Mar. to Dec. 2011 and to 1~3% from Sep. to Dec. 2012.

After early 2003 when the credit card bubble burst thrusting the financial sector into a liquidity crisis and the government imposed stricter regulations on reconstruction projects, house prices started to decline and touched the bottom in early 2005. However, starting early 2005, the price was again on a rapid rise and house prices in capital

regions posted a consistent increase in 2006 with those in local areas starting to fall. This suggests that house prices in capital areas started to decouple with those in local areas, when the actual transaction price as tax base was adopted. In the same period, the government imposed stricter taxes and financial regulations, and interest rates continued to rise.

In late 2007, house prices turn downward and the followed 2008 global financial crisis accelerated the decline of house prices. Afterwards, the housing market in capital areas remained sluggish and the local housing market showed a rise in house prices starting 2010. Since then, house prices in local areas started to rise at a faster pace than those in Seoul and Gyeonggi province for the first time in Korea's history. This phenomenon can be understood in line with the fact that unlike Seoul and Gyeonggi where stricter LTV and DTI regulations were imposed as they have long been considered as speculative areas, local regions have remained relatively free from those regulations.

[Figure 1] Interest Rate, LTV Ratio, House Prices, and Acquisition Tax



The CD interest rate, representing the policy interest rate, was sharply cut from the 5% to 2% at the time of the 2008 financial crisis, suggesting that the monetary policy at that time was relatively moderate. Afterwards, the interest rate remained at a 3% level, tightening policy stance was implemented, and then the overall easing stance has been maintained since 2012.

In September 2002, the LTV ratio was used as a regulatory tool through the mortgage market. The growth rate of actual house prices in this period rose sharply mainly in Seoul and Incheon. The LTV ratio since 2005 has remained flat until today without much fluctuations. According to the data from ministry of strategy and finance, the LTV ratio by financial sector type is 50.5% on average as of June 2012.

Meanwhile, house prices were on a consistent rise since 2001 and touched the peak in the first half of 2002. This is the time when the CD interest rate maintained a low rate, through which liquidity improved and mortgage market expanded. A temporary exemption of the capital gain tax was adopted at this time, too.

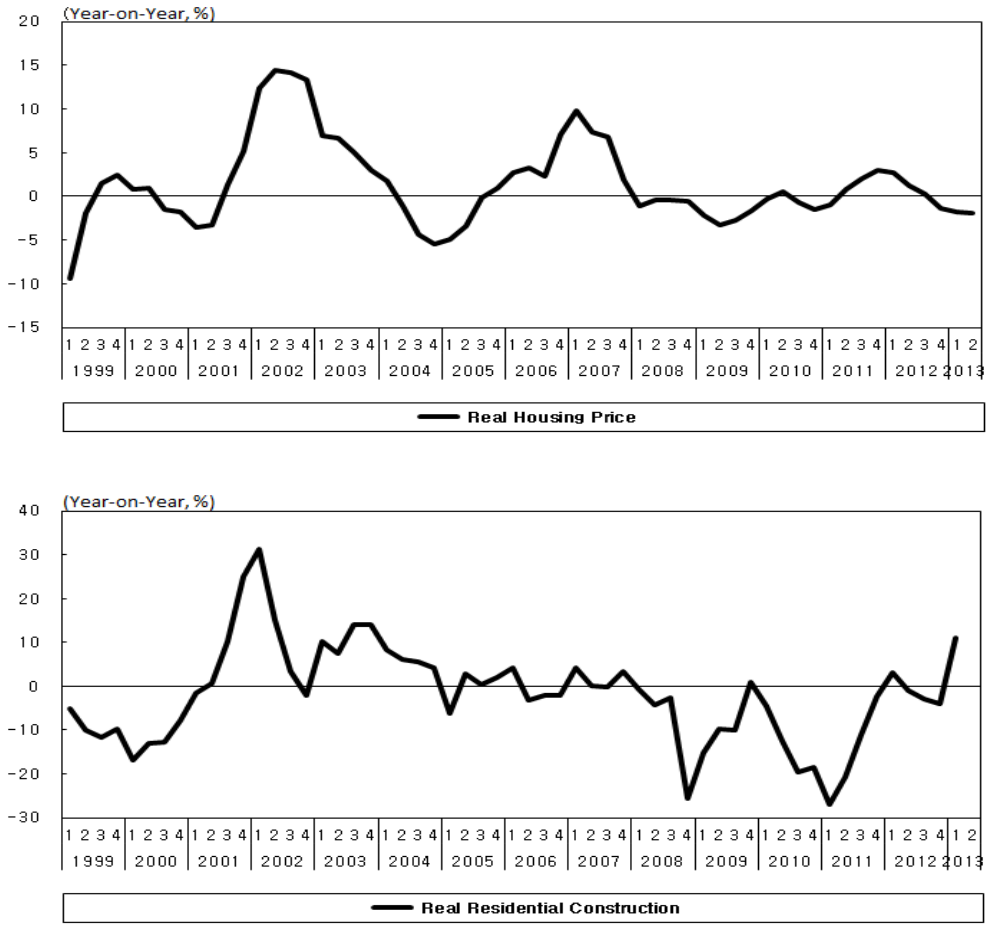
2. Relationship between Housing Market and Relevant Economic

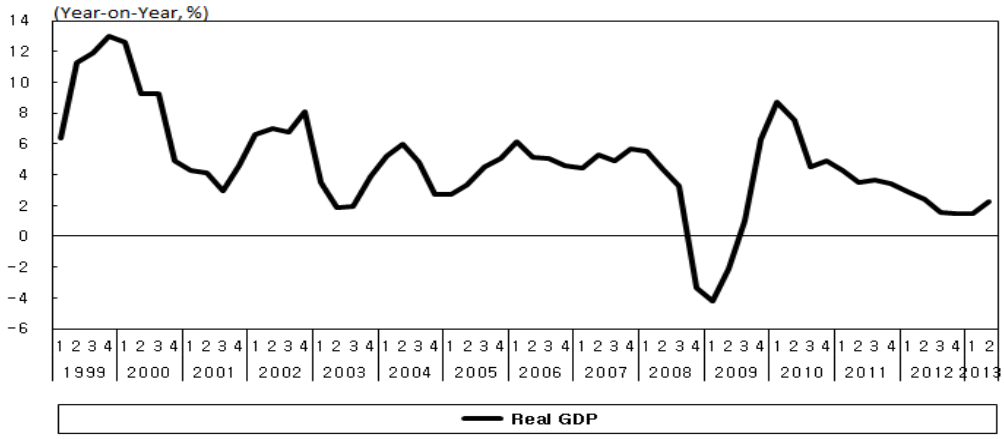
Variables

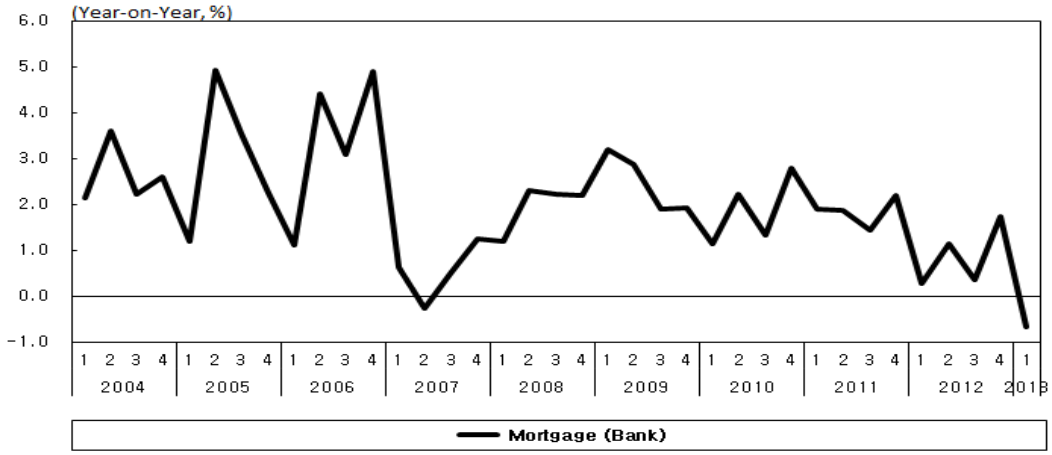
Jae Yung Kim (1992) discussed two elements affecting the housing business cycle: macroeconomic variables represented by national income and monetary aggregates, and housing policy variables represented by housing permit. In this paper, variables related to the housing business cycle include CD interest rate, mortgage loan, house price, and residential building investment in the BOK's national accounts. To examine the housing business cycle, this study used the medium- and long-term time-series data from the first quarter of 1999 to the first quarter of 2013.

As for mortgage loan, time-series data since 2003 were used due to data availability limitations. All data, excluding CD interest rate, were adjusted to year-on-year growth rate and the business cycle among variables is displayed in Figure 2.

[Figure 2] House Price, Mortgage, Construction Investment (residential), and GDP







Meanwhile, through the Granger Causality analysis of variables, the interconnection among them was examined in statistical terms and the result showed that house prices tend to significantly affect mortgage loan. Casual relations among other variables contained some difficulties to be interpreted statistically, but it could be inferred that a virtuous cycle exists between house prices and mortgage loan, given that house prices move ahead of mortgage loan and a rising mortgage loan turns to affect house price.

[Table 1] Ganger Causality Test

Time-series Data: 2004Q4 ~ 2013Q1 (Lags: 2)

Null Hypothesis	Obs	F-Statistic	Prob.
House Mortgage Loan ＼→ Policy Rate	32	0.60431	0.5537
Policy Rate ＼→ House Mortgage Loan		0.06461	0.9376
House Price ＼→ Policy Rate	32	1.11025	0.3441
Policy Rate ＼→ House Price		1.62280	0.2160
Residential Construction Investment ＼→ Policy Rate	32	2.03077	0.1508
Policy Rate ＼→ Residential Construction Investment		0.35874	0.7018
House Price ＼→ House Mortgage Loan ***	32	7.14540	0.0032
House Mortgage Loan＼→ House Price*		2.58107	0.0942

Residential Construction Investment ＼→ House Mortgage Loan	32	1.70967	0.1999
House Mortgage Loan ＼→ Residential Construction Investment		0.31575	0.7319
Residential Construction Investment ＼→ House Price	32	0.52203	0.5992
House Price ＼→ Residential Construction Investment		0.20773	0.8137

Note: *** denote the significance level at 1%. ＼→ means that the former does not granger cause the latter.

Table 2 shows the cycles of housing business, construction investment (residential) business and GDP. It is interesting that the housing business cycle recorded a negative growth rate at its peak and even a very low growth rate could formulate a cycle. This is the period when the global financial market was triggered by the US subprime mortgage crisis in 2008. As for the cycle of residential construction investment, it recorded the lowest peak growth rate of 0.5% and the lowest trough growth rate of -27.1% in the same period as house prices. In the same period, GDP recorded the lowest trough growth rate of -4.2%.

[Table 2] Housing Business Cycle, Construction Business Cycle, GDP Cycle

House Purchase Price Index (actualized)					
Peak-to-Trough			Trough-to-Peak		
Duration	Amplitude		Duration	Amplitude	
	Peak	Trough		Peak	Trough
5 Q	2.5	-3.6	5 Q	-3.6	14.4
10 Q	14.4	-5.5	9 Q	-5.5	9.8
4 Q	9.8	-1.1	1 Q	-1.1	-0.4
4 Q	**-0.4**	**-3.2**	**4 Q**	**-3.2**	**0.5**
2 Q	**0.5**	**-1.5**	**4 Q**	**-1.5**	**3.0**
5.0	-8.3		4.6	8.4	

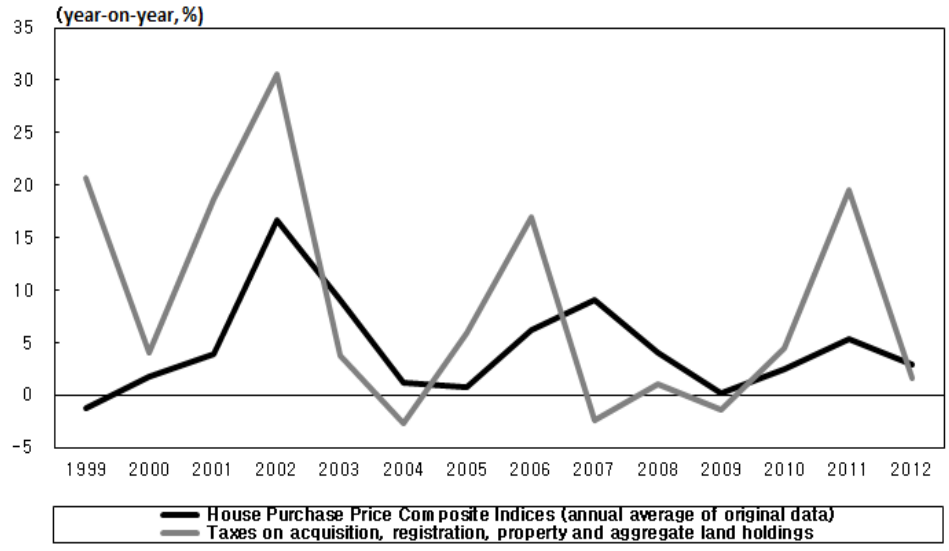
Actual Construction Investment (residential building construction)					
Peak-to-Trough			Peak-to-Trough		
Duration	Amplitude		Duration	Amplitude	
	Peak	Trough		Peak	Trough
			8 Q	-17.0	31.3
3 Q	31.3	-2.0	3 Q	-2.0	14.1
6 Q	14.1	-6.3	4 Q	-6.3	4.1
1 Q	4.1	-3.2	3 Q	-3.2	4.2
7 Q	**4.2**	**-25.7**	**4 Q**	**-25.7**	**0.8**
5 Q	**0.8**	**-27.1**	**4 Q**	**-27.1**	**3.1**

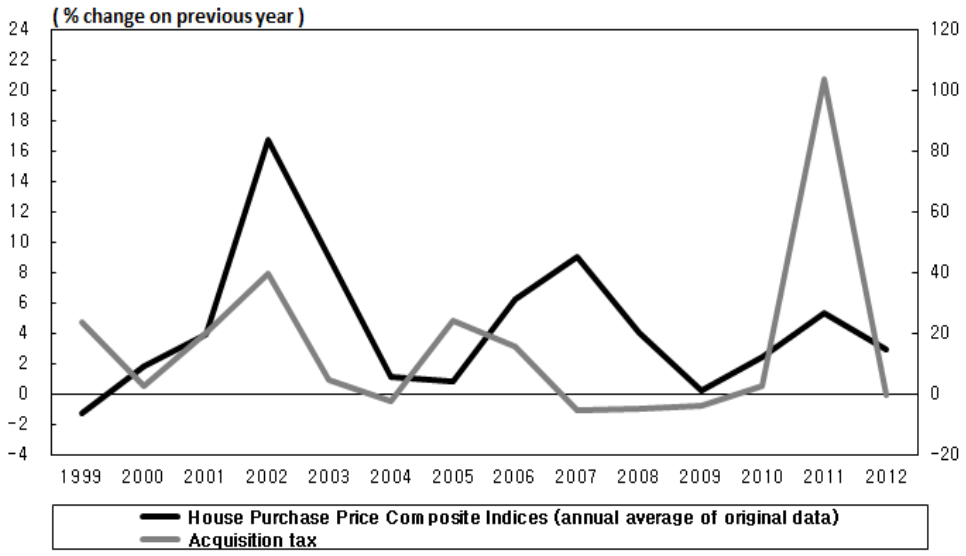
3	3.1	-4.2			
4.2	-21.0		4.3	23.2	

Real GDP					
Peak-to-Trough			Trough-to-Peak		
Duration	Amplitude		Duration	Amplitude	
	Peak	Trough		Peak	Trough
7 Q	13.0	2.9	5 Q	2.9	8.1
2 Q	8.1	1.8	4 Q	1.8	5.9
3 Q	5.9	2.7	4 Q	2.7	6.1
4 Q	6.1	4.5	3 Q	4.5	5.7
5 Q	**5.7**	**-4.2**	**4 Q**	**-4.2**	**8.7**
11 Q	8.7	1.5			
5.3	-6.4		4.0	5.4	

According to Figure 2 showing the year-on-year growth rates for house prices and real estate-related tax revenue, the two are coupled, meaning that as house prices go up, taxes on acquisition, registration, property and capital gain rise, too. This phenomenon is most evident in 2002 and 2011. On the contrary, the growth rate of real estate-related tax revenue stayed low at the trough of house prices in 2004 and 2009, indicating only the growth rate of acquisition tax revenue moving in the same direction as that of real estate-related tax revenue.

[Figure 2] House Price and Real Estate Tax Revenue, House Price and Acquisition Tax





IV. Basic Model for Policy Effect Analysis: Constructing Numerical Economic Model

1. Numerical Economic Model for Representative Consumer and Corporation

This numerical model is a basic model for the DSGE model in this study and aims to give an overview of several policy effects. By dealing with the credit of a corporate as a representative consumer and producer, this model looked into the effects of macroeconomic prudence policy, and through interest rates consisting of subjective discount rate functions of consumer and entrepreneur, it also explored the effects of monetary policy. Also, for the representativeness of fiscal policy, the real estate holding taxes and acquisition-related expenses involving existing houses were established within the inter-temporal budget constraint. Using this numerical model, this study verified the relationship between monetary, macroeconomic prudence and fiscal policies.

The numerical economic model in this paper focused on the numerical method among many for the DSGE model, and then estimated the utility function of unobserved representative consumer through the value function iteration. It also deducted an approximate solution to the problem of consumer's utility maximization in the model under the condition of dynamic state space with several grids. Representative consumer and entrepreneur make decisions at each period and gain utility through consumption (C) and house (h). The problem of representative consumer's utility maximization can be expressed as follow.

$$V_t\left(B_t, H_{t-1}, K_{t-1}\right) = \max[U(C_t^0, H_t^0) + \beta E_t V_{t+1}(B_{t+1}, H_t, K_t)] + BudgetConstraintFunction \quad (1)$$

The utility function of representative consumer and entrepreneur is assumed to conform to the constant elasticity of substitution (CES).

$$U(C_t, H_t) = \frac{1}{1-\zeta}\left[\left(C_t^{\frac{\varepsilon-1}{\varepsilon}} + j_t H_t^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}\right]^{1-\zeta} \quad (2)$$

The elasticity of intra-temporal substitution is set as a parameter, ε, and that of inter-temporal substitution is a parameter, ζ. Consumer is assumed to mortgage (b) a house and house price is set as 1 through normalization. This leads to the following budget constraint equation.

$$C_t + (h_t - (1-\tau)h_{t-1}) + (K_t - (1-\delta)K_{t-1}) + Rb_{t-1} = Y_t + b_t \quad (3)$$

$$Y_t = Z_t\left(K_{t-1}^{\mu} h_{t-1}^{\nu}\right)$$

$$b_t \le ltv \cdot h, \quad 0 \le ltv \le 1, \quad (4)$$

b_{t-1} denotes the amount of existing house mortgage loan and the loan interest to pay for current time is determined by R. The ceiling of a loan is adjusted by the LTV ratio and it is assumed not to exceed the current price of house.

The capital depreciation is set as a parameter, δ, and the depreciation of house is not taken into account since it is only marginal. However, as for the existing house, h_{t-1}, taxes are considered since an owner needs to pay property holding tax. Also, a parameter, τ, is added considering the acquisition tax and moving expense to be incurred when purchasing a first home.

In production function, capital and house are set as an input factor, capital's elasticity on aggregate production as μ, and house's factor elasticity on aggregate production as ν. The stochastic process, Z_t, taking into account technology impacts, is assumed to conform to the Markov chain rule.

Using the Euler equation offers the following first-order optimality conditions.

$$[C_t]U_{C_t} = \left[\left(C_t^{\frac{\varepsilon-1}{\varepsilon}} + j_t H_t^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}\right]^{\frac{\zeta-\varepsilon}{\zeta(\varepsilon-1)}} \quad (5)$$

$$[H_t]U_{C_t} = U_{H_t} + U_{C_{t+1}}\beta\left\{\nu\frac{Y_{t+1}}{H_t} + (1-\tau)\right\} + \lambda_{2t}\cdot ltv \quad (6)$$

$$[b_t]\lambda_{2t} = U_{C_t} - \beta R U_{C_{t+1}} \quad (7)$$

Equations above can be transformed into the following.

$$(1-ltv)U_{C_t} = U_{H_t} + U_{C_{t+1}}\beta\left\{\nu\frac{Y_{t+1}}{H_t}\right\} + \beta\left((1-\tau) - ltv\cdot R\right)U_{C_{t+1}} \quad (8)$$

Consumption, house and capital at the steady state are deducted by solving a multi-equation coupled with nonlinear equation.

2. Parameter

Technology impacts are assumed to follow the five-state Markov stochastic process. At the steady state, an technology impact is set to have 0.75 autocorrelation coefficient and 0.0013 standard deviation, according to Iacoviello (2005). The state of technology impact is represented by Z, and Z has a discretized state space using the Tauchen method (EL1986). z_1 stands for the lowest technology impact, z_3 for the intermittent, and z_5 for the largest.

Technology impacts are assumed to follow the five-state Markov stochastic process. At the steady state, an technology impact is set to have 0.75 autocorrelation coefficient.

$$Z = \begin{bmatrix} z_1 = & 0.951 \\ z_2 = & 0.975 \\ z_3 = & 1 \\ z_4 = & 1.026 \\ z_5 = & 1.052 \end{bmatrix}$$

The stochastic distribution of the Markov chain at the steady state is represented by P, and at each state, the stochastic occurrence of technology impact can be expressed as the following transition probability matrix, P, through the Tauchen method (EL1986).

$$P = \begin{bmatrix} 0.5 & 0.435 & 0.064 & 0.001 & 0.000 \\ 0.128 & 0.519 & 0.323 & 0.029 & 0.000 \\ 0.012 & 0.213 & 0.550 & 0.213 & 0.012 \\ 0.000 & 0.029 & 0.323 & 0.519 & 0.128 \\ 0.000 & 0.001 & 0.064 & 0.435 & 0.500 \end{bmatrix}$$

Figure in row 1 and column 1 indicates when technology impact at current term is z_1, the probability of having the same level of technology impact at subsequent term is 0.5. Number in row 1 and column 2 means that when technology impact at the current time is z_1, the probability of having the z_2 level of technology impact at the subsequent time is 0.435.

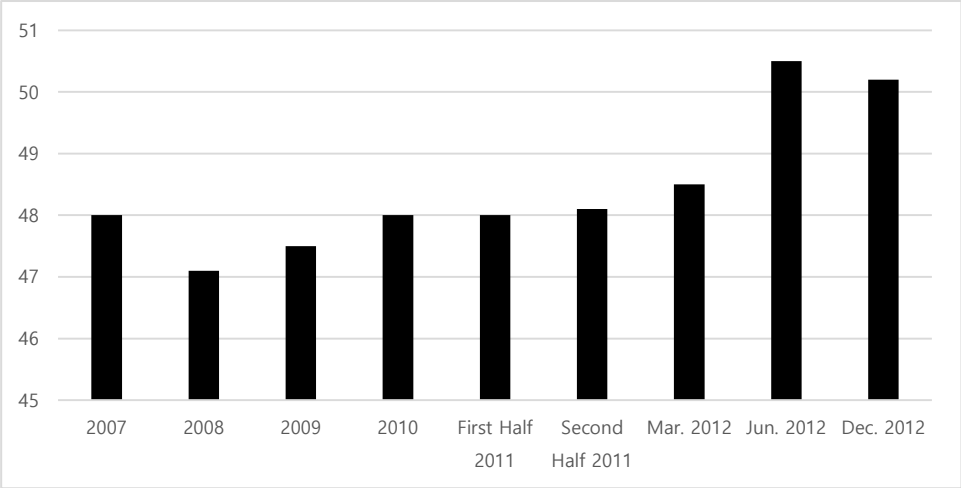
In the model, representative consumer's subjective discount rate, β, is set as 0.99, considering Chung (2007)[1]. The subjective discount rate determines interest rates, R, and this is used as a parameter to pore over effects of monetary policy in the counterfactual experiment based on this basic model. In this way, it is possible to study impacts that the change in interest rates (from high to low) causes on the housing

[1] Kyu Il Chung (2007) set consumer's subjective discount rate to be 0.9898 by combining the average call rate, 8.88%, and inflation, 4.33%, from 1991 to 2006.

market. The intra-temporal substitution elasticity is set as 0.33, according to Song (2013). Here, its estimate is similar to 0.38 by Lee (2003), meaning house and consumption are acting as complementary goods in the model. Also, the inverse number, ζ, of the inter-temporal substitution elasticity is set as 0.3, according to Song (2013), and its inverse number, 1/0.3, is made into the inter-temporal substitution elasticity. Expenses on existing house include taxes—consist of acquisition tax in the previous time and holding tax in the current time—and transaction commissions. These expenses, expressed as a parameter, τ, are set 0.06, considering various elements: Korea's current acquisition tax rate of 4%, holding tax, transaction costs and moving expenses. In the basic model of this study, τ as a parameter to probe the effects of housing-related fiscal policy, were used in a simulation with settings of various tax rates.

The LTV ratio was set 0.5, considering the average figure released in late December 2012 by Korea's Financial Supervisory Service (FSS). Figure 3 demonstrates that Korea's average LTV in all financial sectors has risen consistently since 2008 to near 50% in late June 2012. The LTV ratio was used as a parameter representing macroeconomic prudence policy within the basic model, and simulations applied by different LTV ratios were conducted to check out respective outcomes and effects.

[Figure 3] Time-series Changes in Korea's Average LTV ratio (unit: %)



Source: Ministry of Strategy and Finance, Financial Supervisory Service

Parameters used in this model are as follows.

[Table 3] Calibration and Parameters

Parameters	Fig.	Criteria
μ : Capital elasticity on aggregate production	0.3	Kim and Yang (2004).

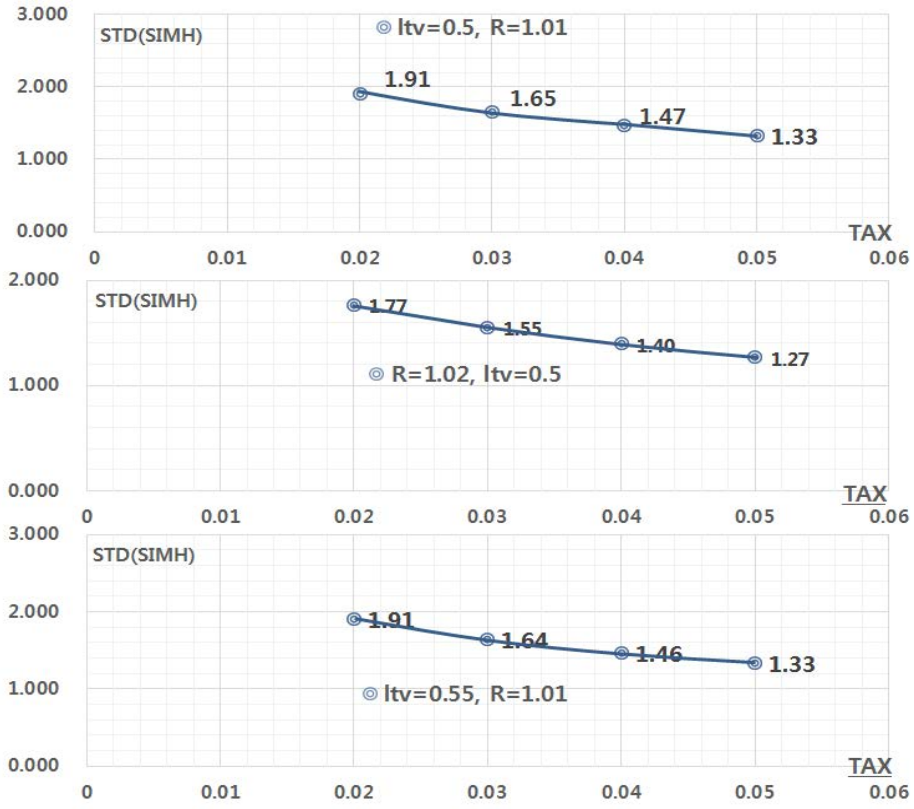
ν : House elasticity on aggregate production	0.03	Imrohoroglu *et al*. (1999)
β : Subjective discount rate for utility	0.99	Chung (2007)
j : Weighted value on housing service	0.1	Share of aggregate houses in GDP is 2.6
ε : Intra-temporal substitution elasticity	0.33	Song(2013a), Lee (2004)
ζ : Inverse number of intra-temporal substitution elasticity	0.3	Song (2013a)
τ : House holding tax, acquisition tax, etc.	0.06	4% acquisition tax and other expenses
ltv : Mortgage loan ratio	0.5	Average ratio among all financial sectors, Kang (2006)
δ_k : Depreciation rate on capital goods	0.03	Iacoviello (2005)

3. Simulation Results

3.1 Impacts of changes in interest rates, LTV and real estate taxes on house price volatility: focusing on changes in real estate taxes

Figure 4 displays results from simulation, showing the impacts of changes in real estate-related taxes on the stability of the housing market with interest rates and the LTV ratio at a certain level.

[Figure4] Impact of Changes in Housing related Taxes on Housing market Volatility



The top panel demonstrates the impacts of real estate taxes on house prices when the LTV ratio is 50% and the interest rate is 1% (4% on annual basis). Real estate taxes here can be classified into acquisition tax at a 'purchasing' stage and holding tax at a 'holding' stage. The former is an initial cost and occurs only once, whereas the latter is an expense to be paid every year. This study is well aware of the fundamental difference between the two taxes, but here it is assumed that all taxes related to real estates are set to move between 2% and 6%.

This simulation was intended to explore the impacts of real estate taxes on the stability of housing market. The result showed that a 2% tax caused 1.91% volatility and that increasing tax rates (3%, 4% and 5%) resulted in the gradual decline in volatility (1.65%, 1.47%, and 1.33%). In other words, the increase in the tax by 1%p caused the volatility to fall at a gradually declining pace of 13.8%, 11% and 9.2%, respectively. This means that a higher tax could certainly decrease the housing market volatility, but not to the degree that the tax level rises.

The middle panel displays the result of simulation of the interest rate of 2% on a quarterly basis under the tightening policy stance. The result found that an increase in the interest rate immediately caused house price volatility to record 1.77%, down by 0.14%p—the decline pace here is 8%--from the case where interest rate is 1% and house price volatility is 1.91%. Under the tightening policy stance, an increase in the real estate-related taxes worked to decrease the house price volatility consistently, as expected. A 1%p increase in the taxes caused the volatility to decline to 1.55%, 1.40% and 1.27%, respectively. The pace of decline, compared to the top panel, is 12.2%, 10% and 9.2%, suggesting that with the tightening policy weighing heavily on the economy, the taxes appear to bring slightly less influence on the housing market volatility.

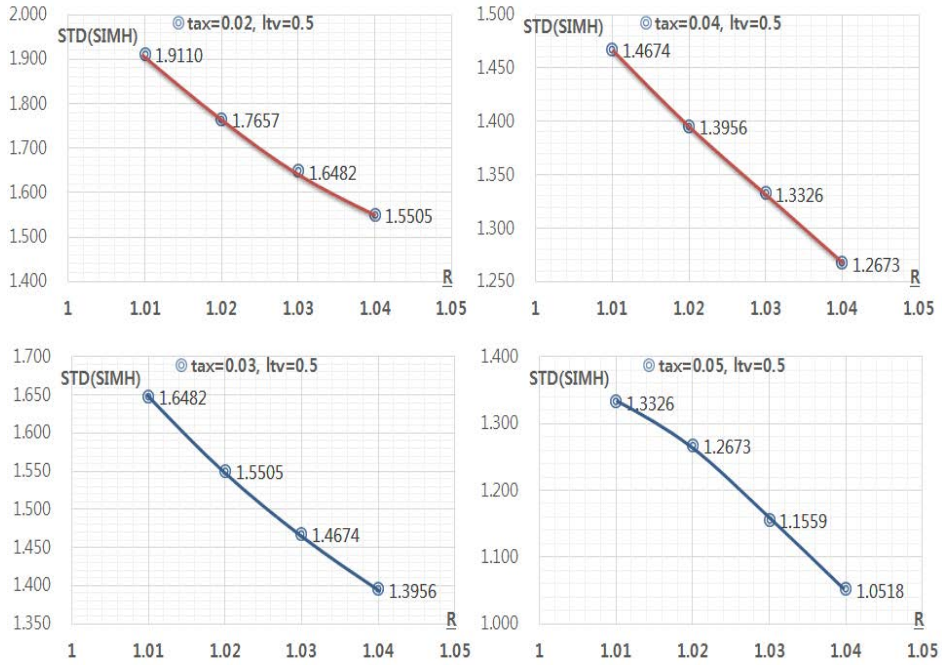
The bottom panel shows the result of simulation where the interest rate is the same as the one in the above panel and the LTV ratio is raised by 5%p: in other words, the mortgage loan ratio is alleviated as a part of macroeconomic prudence policy. An increase in the interest rate immediately decreased the volatility of house prices, and alleviating the LTV ratio with real estate taxes at 2% decreased the volatility to 1.91%, almost the same as the one in the above panel.

These results imply that when the LTV ratio is heightened and therefore mortgage loan ratio decreases, the volatility of house prices does not change significantly. According to the simulation in the basic model, raising interest rates in line with tightening policy could have a meaningful effect of reducing the volatility to a large degree.

3.2 Impacts of changes in interest rate and real estate taxes on house price volatility: focusing on changes in interest rate

Figure 5 contains the result of simulation to see the impacts of real estate taxes on the stability of the market, focusing on changes in interest rate.

[Figure 5] Impacts of Changes in Interest Rate on the Housing Market



The interest rate was set to change from 1% to 2%, 3% and 4% on a quarterly basis. The top left panel demonstrates changes in the house price volatility when real estate taxes are 2% and the LTV ratio is 50%. When the interest rate is 1%, the volatility of house prices records 1.9110. Raising the interest rate to 2%, 3% and 4% resulted in the decline in volatility at 1.7657, 1.6482 and 1.5505, respectively, meaning that the higher the interest rate is, the lower the house price volatility is. Also, the volatility is reduced at a gradually slower pace. This means that a higher interest rate could certainly decrease the house price volatility, but not to the degree that the interest rate rises.

The top right panel shows the relationship between changes in the interest rate and housing market volatility when real estate taxes are 4% and the LTV ratio is 50%. The result found that an increase in real estate taxes immediately caused house price volatility to record 1.4674, down by 0.4436 from the case where the tax is 2% and volatility is 1.9110. Under such condition, when the interest rate goes up to 2%, 3% and 4%, the house price volatility records 1.3956, 1.3326 and 1.2673, respectively, suggesting that a rising interest rate would help decrease the volatility of house prices.

The bottom left panel shows the relationship between changes in the interest rate and house price volatility under the economy with real estate taxes at 3% and the LTV ratio at 50%. When the interest rate is 1%, the house price volatility is 1.6482. When the

interest rate is 2%, the house price volatility is 1.5505. The decline in the volatility here is equal to the one in the top left panel when the interest rate changes from 3% to 4% under the economic structure with the real estate taxes at 2% and the LTV ratio at 50%. Not only that, when the interest rate changes from 3% to 4%, the house price volatility declines from 1.4674 to 1.3956, and the decline as well is equal to the one in the top right panel when the interest rate changes from 1% to 2% under the economic structure with the real estate taxes at 4% and the LTV ratio at 50%. This suggests that with the LTV ratio intact, a change in the house price volatility by the 1%p change in the real estate taxes could be the same as the change by the 2%p change in the interest rate. This can be interpreted to mean that changing real estate taxes could bring larger impacts on the volatility of house prices than changing interest rates could.

The bottom right panel displays the simulation with real estate taxes at 5% and the LTV ratio at 50%. Here, when the interest rate is 1%, house price volatility is 1.3326. And, when the interest rate rises to 2%, 3% and 4%, the house price volatility decreases to 1.2673, 1.1559 and 1.0518. Like other panels, a higher interest rate resulted in less volatility of house prices.

V. Establishing the DSGE Model for Policy Effect Analysis

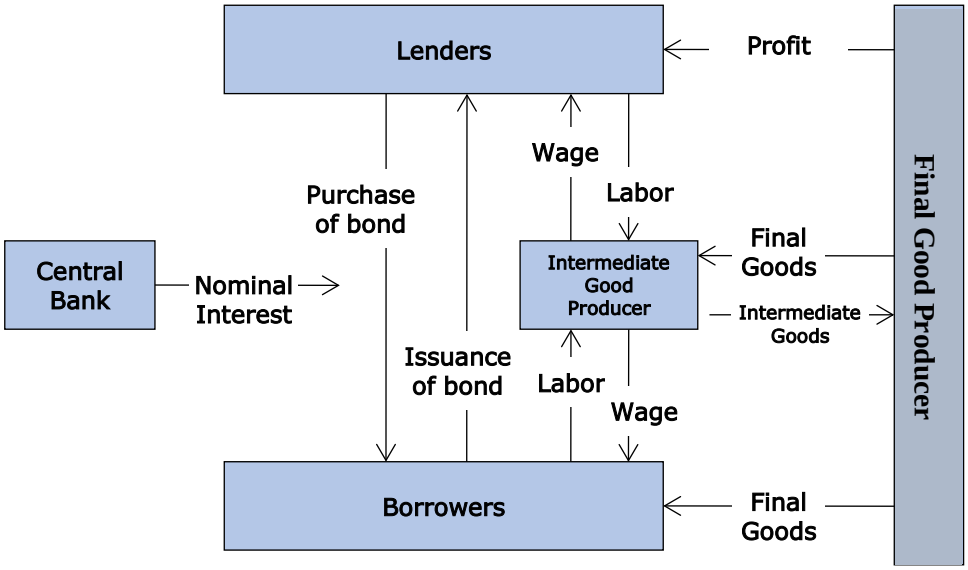
In the DSGE model, the economic structure largely consists of central bank, households and corporations. Households are classified into borrowers and savers, while the former pays taxes on house transactions and holding and mortgages a house, the latter provides a loan to borrowers and takes the loan interest as its revenue. Corporations are classified into intermediate goods producers and final goods producers. The former is assumed to be able to freely use house as its input factor by turning it into capital without adjustment costs.

Key parameters of this model are based on the basic model in Section 4: the interest rate (R) representing monetary policy, mortgage loan ratio (ltv) representing macroeconomic prudence policy, and house-related expenses and taxes, such as acquisition and holding taxes (τ) representing fiscal policy.

The model in this paper took account of economic structures for several policy effect analyses suggested by Crowe *et.al* (2011) and was established by transforming the Iacoviello (2005)'s model into a DSGE model with Korea's macroeconomic data in it. Given characteristics of the relationship between consumption and housing in Korea, the DSGE model should have inseparable function as its utility function, but this study used a log to set the separable utility function as its basic function.

Unlike Section IV canvassing policy effects through the basic model, Section V intended to delve into policy effects by diversely analyzing structural policy effects in the interconnection among several economic participants as shown in Figure 6.

[Figure 6] Economic Participants in the DSGE Model



1. Corporations

Corporations are classified into intermediate goods producers and final goods producers. A model for corporations is based on the one by Kiyotaki and Moore (1997) and Bernanke *et al.* (1999)

1.1 Intermediate goods producer

Intermediate goods producers use capital, K, house, H [2], and households' labor, N_1, N_2, as their input factors and produce intermediate goods needed to produce final goods. Here, production function is assumed to follow the Cobb-Douglas production function.

$$Y_t = Z_t \left(K_{t-1}^{\mu} H_{t-1}^{\nu} \right) \left(N_{1t-1}^{\alpha(1-\mu-\nu)} N_{2t-1}^{(1-\alpha)(1-\mu-\nu)} \right) \tag{9}$$

In equation (9), Z_t is assumed to follow AR(1) as a production technology to be applied to produce intermediate goods.

$$\ln Z_t = \ln Z + \rho_z \ln Z_{t-1} + \varepsilon_{Z,t},\ \varepsilon_{Z,t} : iid \sim N\left(0; \sigma_z^2\right) \tag{10}$$

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[2] It is assumed that house is capitalized without constraints and its loan amount is limited through mortgage loan ratio.

ρ_z is auto-regression of technology impacts, and it is assumed that $-1<\rho_z<1$ is $Z>0$. ε_{Zt} denotes technology impacts.

The utility maximization problem for intermediate goods producers can be expressed as below.

$$\max_{\left\{C_{et}, b_{et}, K_t, H_{et}, N_{1,t}, N_{2,t}\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \gamma^t \ln C_{et},$$

s.t

$$\begin{aligned} &\frac{Y_t}{X_t} + b_{et} = C_{et} + \frac{R_{t-1}}{\pi_t} b_{et-1} + w_{1,t} N_{1,t} + w_{2,t} N_{2,t} \\ &+ K_t - \left(1-\delta_k\right) K_{t-1} + \left(H_t - \left(1-\tau_e\right) H_{t-1}\right) q_t \end{aligned} \tag{11}$$

τ_e denotes tax expenses incurred by buying and holding house at t-1 time, and they are assumed to be imposed at a fixed rate according to the current price of house, like holding tax. They are also assumed to include adjustment cost, real estate transaction commission, moving cost, acquisition tax, etc. In this model, τ_e as a parameter representing fiscal policy is used for the simulation on the effect of housing market stability. Then, house mortgage loan for corporate production, denoted as b_{et}, can be expressed as below.

$$b_{et} \le \frac{\pi_{t+1}}{R_t} ltv_e q_{t+1} H_{e,t},\ 0 \le ltv_e \le 1 \tag{12}$$

House mortgage loan is assumed to be under the constraints of the LTV ratio, ltv, which cannot exceed 1 so that the loan amount does not exceed house price, $q_{t+1}H_{e,t}$. In this model, ltv works as a parameter representing macroeconomic prudence policy through the simulation. A parameter, R, represents monetary policy.

1.2. Final goods producer

It is assumed that in a monopolistic competition market, a final goods producer buys $Y_t(g)$ intermediate goods at P_t^g price and then produces Y_t final goods at $P_t(g)$ price.

$$Y_t = \left(\int_0^1 Y_t(g)^{(\xi-1)/\xi}\, dg\right)^{\frac{\xi}{\xi-1}} .$$

Meanwhile, the final goods producer is assumed to adjust product prices with (1-θ) probability, as shown in Calvo (1983). Final goods producer gains profits in the existing monopolistic competition market and the profits are transferred to savers. Final goods producer, through cost minimization, sets the price of final goods made up of several intermediate goods as follow.

$$P_t = \left(\int_0^1 P^{i_t}(g)^{(1-\xi)} dg \right)^{\frac{1}{1-\xi}} \quad .$$

The lowest price, $P_t^*(g)$, satisfies the equation below.

$$\sum_{i=0}^{\infty} \theta^i E_t \left(\beta \frac{C_t}{C_{t+i}} \left(\frac{P_t^*(g)}{P_{t+i}^*} - \frac{X_t}{X_{t+i}} \right) Y_{t+i}(g) \right) = 0 \tag{13}$$

Price is expressed as, $P_t = \left(\theta P_{t-1}^{\xi} + (1-\theta) P_t^{*(1-\theta)} \right)^{\frac{1}{1-\xi}}$.

X is a mark-up. Aggregate supply curve is expressed as $\widehat{\pi_t} = \beta \widehat{\pi_{t+1}} - k \widehat{X_t} + \widehat{\varepsilon_{u,t}}$.

2. Households

Households are classified into two categories of borrowers and savers. Because the two have different subjective discount rates on current and future consumption, borrowing and saving occur. The model for households is based on Campbell and Hercowitz (2006), Iacoviello (2005), Iacoviello and Neri (2010), and Monacelli (2006).

2.1 Savers

Savers gain utility by consuming final goods and through housing service at each period, and get disutility by offering their labor to intermediate goods producers. The utility between consumption and housing is set as a separable utility function using a log function.[3)] Savers have the utility function below.

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3) This is different from the inseparable utility function in the basic model. When the economic structure shows a strong coupling between consumption and housing, the function of complementary goods is needed. However, this study adopts a complete model in which consumption and housing are independent from utility function, act as a choice variable for economic agents, and are made to be under the inter-temporal budget constraint.

$$U\left(C_{1,t},H_{1,t},N_{1,t}\right)=\left\{\ln C_{1,t}+j_t\ln H_{1,t}-\frac{N_{1,t}^{\eta_1}}{\eta_1}\right\} \tag{14}$$

C_{1t} stands for consumption[4], H_{1t} for housing service, $N_{1,t}$ for labor hour, η for inverse number of labor supply elasticity, and j for weighted value of housing service. *j* denotes impacts on house demand and is assumed to follow the stochastic process.

$$\ln j_t=\ln j+\rho_j\ln j_{t-1}+\varepsilon_{j,t},\ \varepsilon_{j,t}:iid\sim N(0;\sigma_j^2) \tag{15}$$

Problem of utility maximization of savers is expressed as below.

$$\max_{\left\{b_{1,t}C_{1,t}H_{1,t}N_{1,t}\right\}_{t=0}^{\infty}} E_0\sum_{t=0}^{\infty}\beta_1^t U\left\{C_{1,t},H_{1,t},N_{1,t}\right\}$$

s.t.

$$w_{1,t}N_{1,t}+b_{1,t}+f_t=C_{1,t}+\left(H_{1,t}-\left(1-\tau_1\right)H_{1t-1}\right)q_t+\frac{R_{t-1}}{\pi_t}b_{1,t-1} \tag{16}$$

β_1 denotes a saver's subjective discount factor, and is assumed to be $\beta_1>\beta_2$ with β_2 denoting a borrower's subjective discount factor. Calculating the first-order optimality condition for intermediate goods producers, savers and borrowers requires $\beta_1>\beta_2>\gamma$, and the actual estimation of parameters meets this requirement. This means that savers function to offer loans to producers and borrowers.

Under the inter-temporal budget constraint, savers consume the earned income ($w_{1,t}N_{1,t}$), profits given from intermediate goods producers (f_t), and the interest on the loan lent at previous time ($\frac{R_{t-1}}{\pi_t}b_{1,t-1}$). They invest on housing assets $\left((H_{1,t}-(1-\tau_1)H_{1t-1})q_t\right)$, and they borrow ($b_{1,t}$). Here, $b_{1,t}$ is expressed as a negative number, hence $-b_1=b_2+b_e$ at the steady state. τ_1 denotes tax costs incurred by buying a house at previous time and holding it at current time, and is assumed to be imposed at a fixed rate according to current price of house, like holding tax.

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[4] Subscript 1 stands for savers, 2 for borrowers, and e for intermediate goods producers.

2.2 Borrowers

Borrowers mortgage a house from savers and use earned income to consume, invest and pay the interest on the existing loan. Borrowers face the optimization problem as below.

$$\max_{\{b_{2,t}C_{2,t},H_{2,t},N_{2,t}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta_2^t \left\{ \ln C_{2,t} + j_t \ln H_{2,t} - \frac{N_{2,t}^{\eta_1}}{\eta_2} \right\} \tag{17}$$

The budget constraint equation is displayed below.

$$w_{2,t}N_{2,t} + b_{2,t} = C_{2,t} + (H_{2,t} - (1-\tau_2)H_{2t-1})q_t + \frac{R_{t-1}}{\pi_t} b_{2,t-1} \tag{18}$$

$$b_{2,t} \le ltv_2 \beta E_t \left(q_{t+1}\pi_{t+1}\right) H_{2,t}, \quad 0 \le ltv_2 \le 1, \tag{19}$$

3. Central Bank

When implementing monetary policy to stabilize inflation and economy, the central bank is assumed to follow the Taylor's Rule which responds to gaps in inflation and output. In other words, the central banks uses the nominal interest rate R as monetary policy which responds to inflation gap π and output gap Y. Monetary policy impact, denoted as $\varepsilon_{R,t}$, can be expressed as below after log-linearizing.

$$\widehat{R_t} = \gamma_R \widehat{R_{t-1}} + \left(1-\gamma_R\right)\left(\left(1+\gamma_\pi\right)\widehat{\pi_{t-1}} + \gamma_Y \widehat{Y_{t-1}}\right) + \widehat{\varepsilon_{Rt}} \tag{20}$$

4. Market clearance conditions

All participants of the economy meet budget constraints, respective credit constraints and the first-order optimality conditions. At the same time, market is cleared at the steady state. Log-linearizing the housing market for market clearance conditions can be expressed as the following equation (21). The housing market at the steady state is $H_e + H_1 + H_2 = 1.$

$$0 = h_e \widehat{h_{et}} + h_1 \widehat{h_{1t}} + h_2 \widehat{h_{2t}} \tag{21}$$

Equation (22) suggests that the borrowed money of borrowers is to be met by the loan of savers. At the steady state, $b_e + b_2 + b_1 = 0$.

$$0 = b_e \widehat{b_{et}} + b_1 \widehat{b_{1t}} + b_2 \widehat{b_{2t}} \tag{22}$$

In equation (23), aggregate income is equal to aggregate consumption. Here, the aggregate consumption consists of the followings: final goods consumed by borrower C_2 , saver C_1 and corporations C_e ; housing H ; and corporate investment on capital K , $I_t = I_{H_t} + I_{K_t}$.

$$0 = \frac{C_e}{Y}\widehat{C_{et}} + \frac{C_1}{Y}\widehat{C_{1t}} + \frac{C_2}{Y}\widehat{C_{2t}} + \frac{I}{Y}\hat{I}_t - \hat{Y}_t \tag{23}$$

5. Estimation and Calibration

5.1 Estimation

Using the minimum distance method[5)], parameters were estimated on individual economic agent's subjective utility discount rate (β_1, β_2, γ), monetary policy coefficients following the Taylor's Rule ($\gamma_r, \gamma_\pi, \gamma_y$), elasticity coefficients following the Cobb-Douglas production function (μ, ν), labor productivity proportion by savers and borrowers (α), the Loan-to-Value ratio (ltv), autoregressive rates of inflation, house demand and technology impacts (ρ_π, ρ_j, ρ_Z), and standard deviations of interest rates, inflation, house demand and technology impacts ($\sigma_r, \sigma_\pi, \sigma_j, \sigma_A$)

The time-series data used for parameter estimation covers the period from the first quarter of 1999 to the fourth quarter of 2012 and includes Kookmin Bank's house price index, BOK's GDP deflation-adjusted inflation, and GDP and call rate in BOK's national accounts.

House prices and GDP were applied by BP filter to remove the trend components so that its stationary is secured. The output gap was drawn using the discrepancy between the BP filter-applied trend and long-linearized GDP.

The Cholesky Ordering for unrestricted VAR was set as interest rates, house price, inflation and output gap, and impulse response functions of each of them were deducted. Results of estimating parameters' coefficients to minimize the distance between data and DSGE impulse responses are summarized in Table 6.

Intermediate goods producer's subjective utility discount rate recorded 0.98, suggesting high standard deviation, but this is consistent with Iacoviello (2005) whose

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[5)] The minimum distance method is based on the one by Iacoviello (2005).

equilibrium rate of interest is assumed to be twice as high, taking into account corporate's internal rate of return. Not only that, the discount rate is estimated to be lower than saver's subjective utility discount rate, hence consistent with the first-order optimality conditions of savers and borrowers at the steady state.

The LTV ratio ltv is consistent with the average rate in Korea's entire financial sectors, which is 50.2%. As a representative macroeconomic prudence policy, the LTV ratio of 55% and 60% were used in simulations.

[Table 4] Parameter Estimation

Parameters	Figures	Standard Deviation	Description
β_1	0.990	0.229	Saver's subjective utility discount rate
β_2	0.960	0.157	Borrower's subjective utility discount rate
γ	0.980	1.268	Intermediate goods producer's subjective utility discount rate
γ_r	0.677	0.110	Monetary policy's interest rate persistence
γ_π	0.147	0.404	Monetary policy's inflation responsiveness
γ_y	0.010	0.046	Monetary policy's business responsiveness
μ	0.400	0.121	Capital elasticity to production
ν	0.020	0.047	Housing elasticity to production
α	0.85	0.282	Saver's earned income ratio
ltv	0.500	0.456	Intermediate goods producer's LTV
ltv_2	0.510	11.51	Borrower's LTV
ρ_π	0.292	0.162	Autoregressive rate of inflation impact
ρ_j	0.870	0.040	Autoregressive rate of house demand impact
ρ_Z	0.242	0.238	Autoregressive rate of technology impact
σ_r	0.135	0.026	Monetary policy impact on interest rate
σ_π	0.435	0.086	Inflation impact
σ_j	11.01	24.31	House demand impact
σ_A	2.256	1.168	Technology impact

Meanwhile, monetary policy's inflation responsiveness is 0.147, and after applying the Taylor's Rule, that can be expressed as follow.

$$\widehat{R}_t = 0.68\hat{R}_{t-1} + 0.32\left(0.46\hat{\pi}_{t-1} + 0.031\hat{y}_{t-1}\right) \tag{24}$$

As for monetary policy, response coefficients of interest rate persistence, inflation and output gap applied by the Taylor's Rule might not be consistent with the equation (24) estimation in the model and with the coefficients estimated through regression analysis of interest rates with separate data. But, these inconsistent coefficients do not greatly affect actual simulation result.

5.2 Calibration

In this study, calibrations of house demand impact, Calvo's price fluctuation probability, labor supply elasticity coefficient, adjustment cost coefficients of house and capital, house holding tax, and capital goods depreciation rate were cited from the estimation and calibration in preceding literatures,

[Table 5] Calibration and Parameters

Parameters	Figure	Citation
j : House demand impact	0.2	Hyun-Euy Kim·Jun Myung Woo (2007) considered
θ : Calvo's price fluctuation probability	0.75	Jin Hyuk Yoo·Heejoo Ahn (2006), Gun Hong Kim (2011)
η_i, n_{ii} : Inverse number of labor supply elasticity coefficient	1.01	Iacoviello (2005)
ψ_k, ψ_{H_e} : Adjustment cost coefficients of capital and house	2, 0.03	Iacoviello (2005)
$\tau_e = \tau_{C_1} = \tau_{C_2}$: House holding tax, etc.	0.01	House holding tax considered
δ_k : Depreciation rate of capital goods	0.03	Iacoviello (2005)

In particular, the parameter τ , representing fiscal policy such as house holding tax, is set to change to 1% and 3% in simulations.

VI. Results from Simulations

1. Monetary Policy Impacts on Aggregate Production: Simulation on Macroeconomic Prudence and Taxation Policies

Figure 7 shows house price channels in the model. For instance, provided that tightening policy caused the base interest rate to rise by 25bp as of the first quarter, this would lead to shrinking house demand, falling house price, and rendering asset value. Falling asset value dampens the value of house as a collateral, thereby weakening

borrower's credit and consumption capacity. As a result, the rise in interest rates contracts business conditions, and the contraction is further magnified by the fall in house price.

[Figure 7] House Price Mechanism

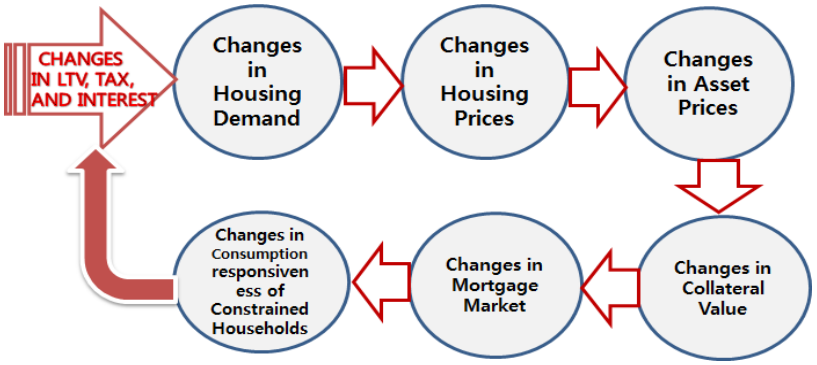


Figure 8 demonstrates the impacts of monetary policy on aggregate production through the simulation on macroeconomic prudence and fiscal policies. Provided that real estate-related taxes are 1% and the LTV ratio is 50%, the 25bp increase in interest rates by tightening policy caused the aggregate production to drop by 0.294% at first and then by 0.801% cumulatively. Each time that the LTV ratio rises by 5%p, cumulative loss of production reaches 0.827% and 0.856%. Early loss of production is merely 0.296% and 0.298%, but when real estate taxes rise to 3%, the cumulative loss of production reaches 0.811%, 0.835% and 0.837%, implying that costs incurred by real estate taxes work to shrink production further.

[Figure 8] Monetary Policy Impacts on Aggregate Production

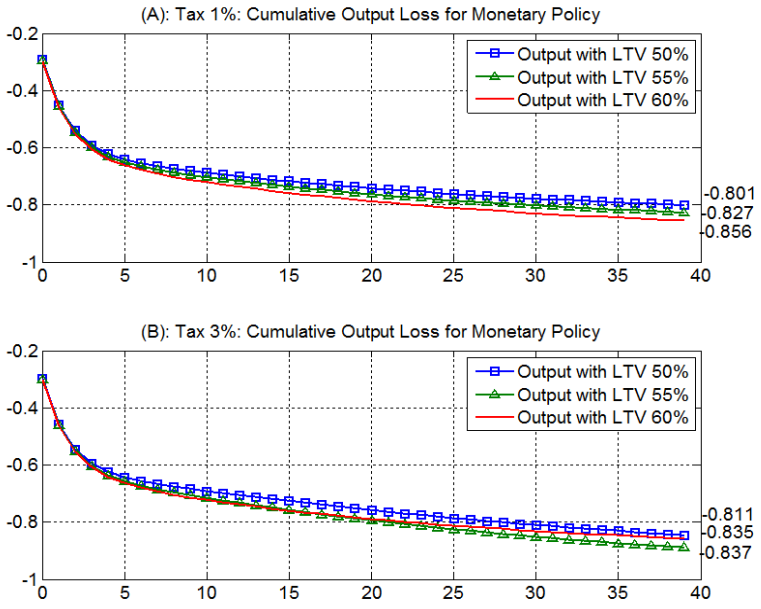


Table 6 displays the impact of a 25bp increase in interest rates on fluctuations in output gap in each economic structure. In the economic structure with a 1% interest rate (quarterly basis) and 1% real estate tax, the impact of a 25bp increase in interest rate results in the output gap standard deviation at 0.168%. Under the same condition, a 3% real estate tax causes the output gap standard deviation to record 0.21%, meaning that a higher tax could weaken production further.

[Table 6] Impacts of Interest Rates on Output Gap Fluctuation in Each Economic Structure

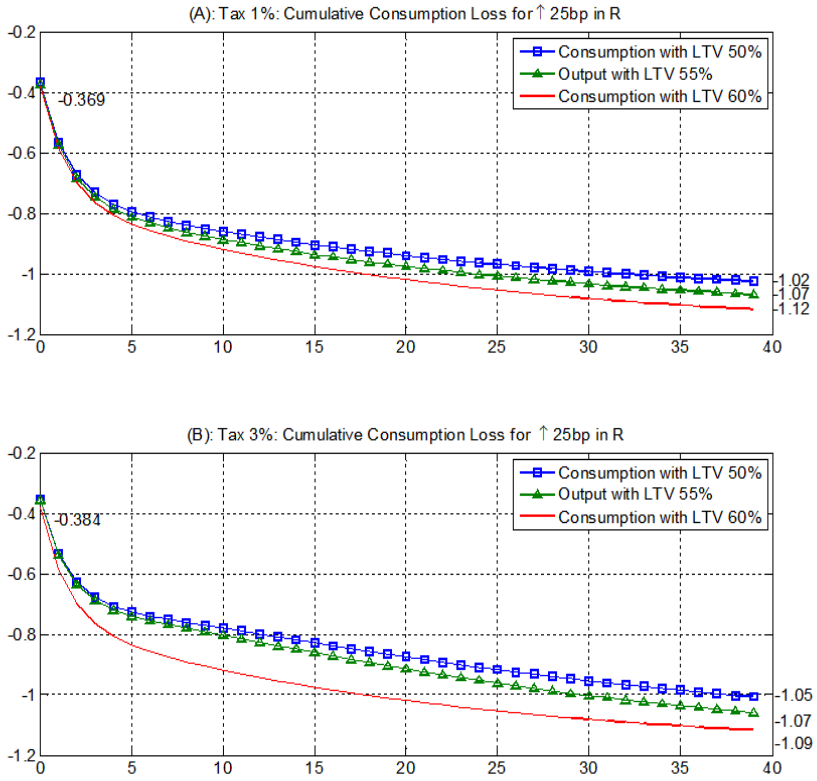
Category	Economic Structure 1	Economic Structure 2
Interest rate structure	R=1/0.99=1%	R=1/0.99=1%
Real estate-related tax structure	$\tau = 1\%$	$\tau = 3\%$
Standard deviation of output gap that deviated from the trend during 20 quarters.	0.168%	0.217%

2. Monetary Policy Impacts on Consumption: Simulation on Macroeconomic Prudence and Fiscal Policies

Figure 9 displays monetary policy impacts on consumption through simulation on macroeconomic prudence and fiscal policies. The impact on consumption by tightening policy through changes in real estate taxes is most noticeable at the time of interest rate impact. In other words, when real estate taxes are 1%, a 25bp rise in interest rates causes consumption to drop by 0.369% at the time of impact. On the other hand, when the real estate tax is up to 3%, consumption decreases further by 384%.

Like the impact of monetary policy on aggregate production, the impact by changing macroeconomic prudence policy does not seem quite different at the time of impact. However, when the real estate tax is 1% and the LTV ratio is set 50%, 55% and 60%, the cumulative loss reaches -1.02%, -1.07% and -1.12%, respectively. When the real estate tax is 3% and the LTV ratio is set 50%, 55% and 60%, the cumulative loss reaches –1.05%, -1.07% and -1.09%.

[Figure 9] House Price Rise and Consumption



3. Monetary Policy Impact on Housing Market: Simulation on Macroeconomic Prudence Policy

At the steady state with almost zero impacts (interest rate impact is 0.0009), the house price volatility in a simulated economic structure is 0.0706% when the LTV ratio is 50%, and 0.0727% when the LTV ratio is 55%. This suggests that as the regulations are eased further as a part of macroeconomic prudence policy, the house price volatility at the steady state rises, too, but only a little.

[Table 7] House Price Volatility in a Simulated Economic Structure

Category	Economic Structure 1	Economic Structure 2
Interest rate structure	R=1/0.99=1%	R=1/0.99=1%
Real estate-related tax structure	$ltv = 50\%$	$ltv = 55\%$
Standard deviation of output gap that deviated from the trend during 20 quarters.	0.0706%	0.0727%

Figure 10 demonstrates the impact of tightening policy on house prices in the economic structure with the 50% LTV ratio through a simulation. Like Panel A, when interest rate impact occurs due to tightening policy, the output gap records -0.294% at the state of having only real interest rate working—in other words, real debt dynamics and collateral effect, but -0.364% at the state of having both house's collateral value and nominal interest rate working inside the model with falling collateral value affecting the overall economy—in other words, nominal debt dynamics and collateral effect.

Panel C displays that the fall in house prices affected by the rise in interest rates accelerates further at the state of real debt dynamics and collateral effect. When the impact of interest rate rise occurs, house prices decrease by 0.29% at the state of real debt dynamics and collateral effect, but 0.353% at the state of nominal debt dynamics and collateral effect.

[Figure 10] Tightening Policy, GDP, House Price (economic structure with the LTV ratio at 50%)

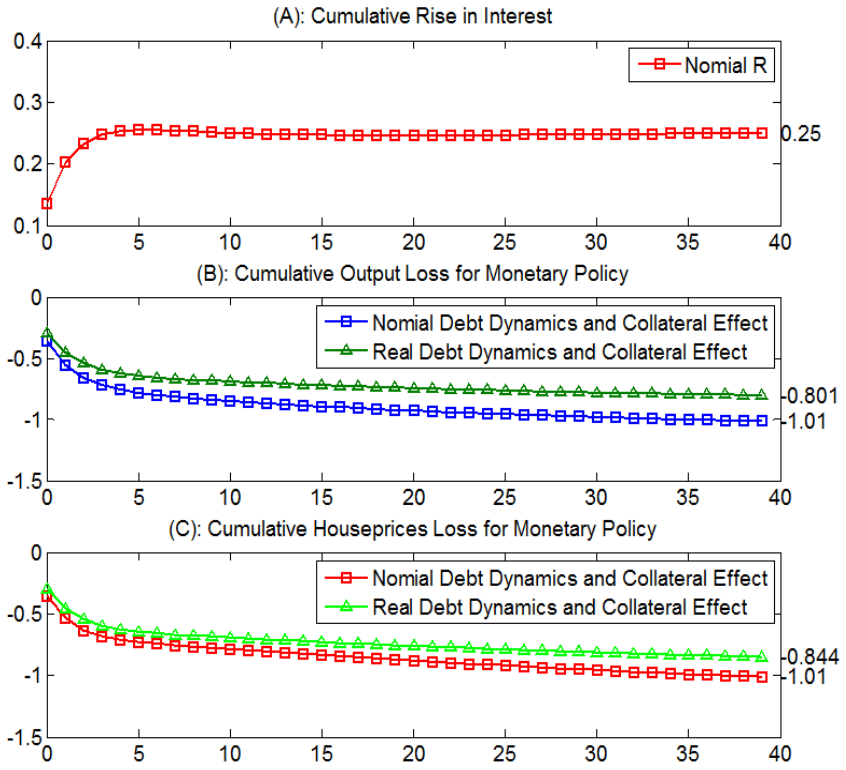


Figure 11 demonstrates the impact of tightening policy on house prices in the economic structure with the 55% LTV ratio through a simulation. At the state of real debt dynamics and collateral effect, the output gap declines 0.296%, showing a slightly steeper fall than the case in Figure 8. This implies that as macroeconomic prudence

policy is eased further, the output gap by tightening policy decelerates faster. At the state of nominal debt dynamics and collateral effect, the output gap records -0.368% at the impact of interest rate rise, showing the magnification by collateral effect. In Panel C, the fall in house prices triggered by the impact of interest rate rise is steeper at the state of nominal debt dynamics and collateral effect (0.356%) than at the state of real debt dynamics and collateral effect (0.298%).

[Figure 11] Tightening Policy, GDP, House Price (economic structure with the LTV ratio at 55%)

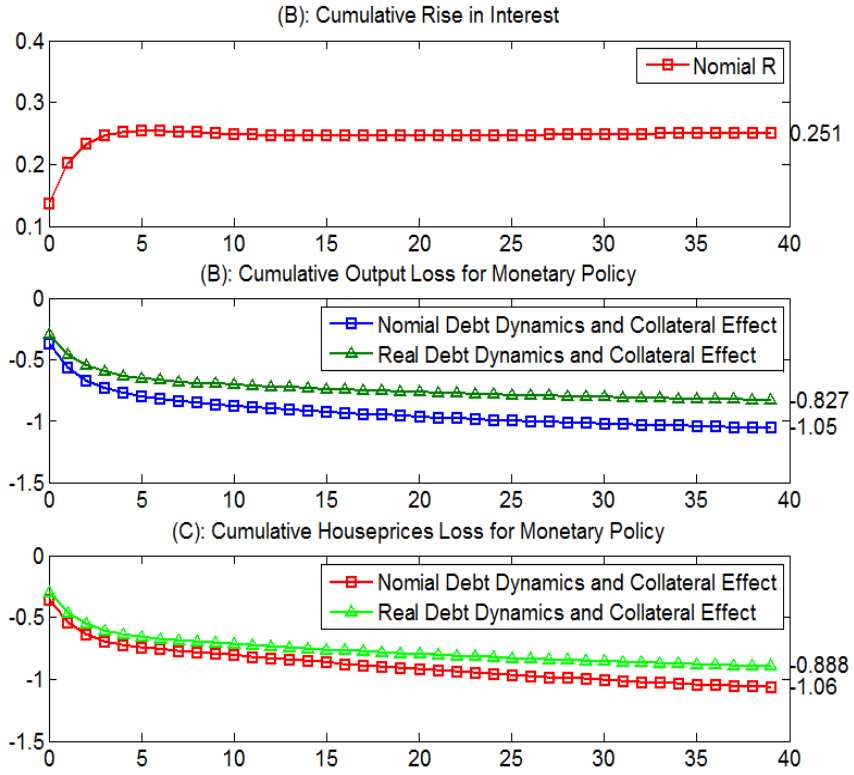
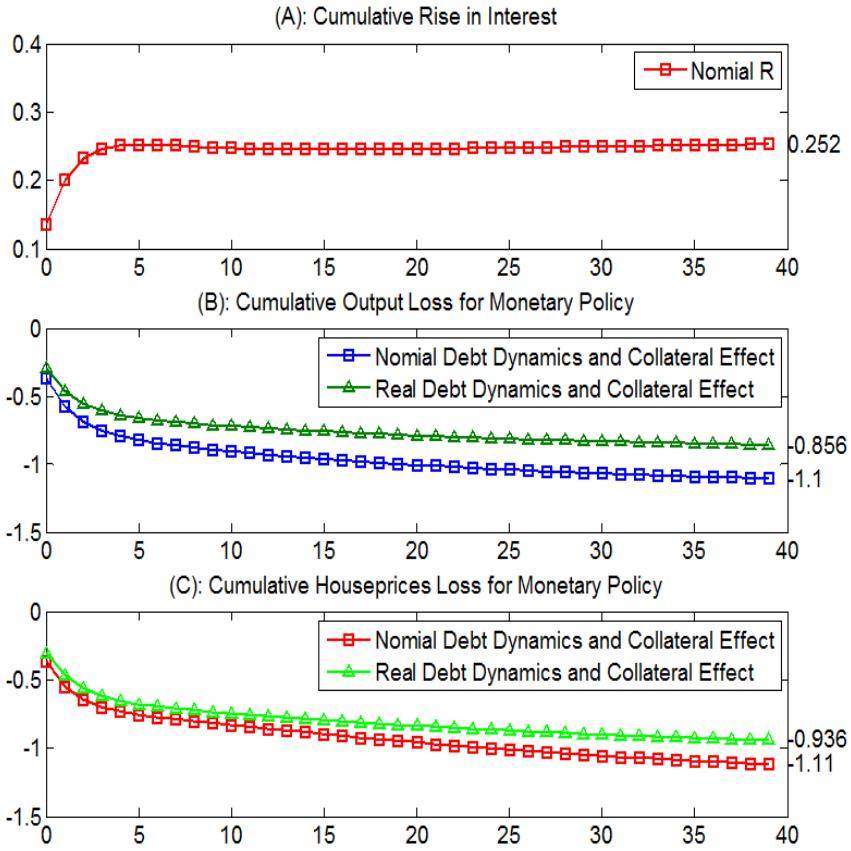


Figure 12 demonstrates the impact of tightening policy on house prices in the economic structure with the 55% LTV ratio through a simulation. At the state of real debt dynamics and collateral effect, the output gap records 0.298%, a slightly larger decline than Figure 9. At the state of nominal debt dynamics and collateral effect, the output gap records –0.375%, showing a higher magnification by collateral effect.

Panel C displays that the fall in house prices affected by the rise in interest rates magnifies further at the state of real debt dynamics and collateral effect. When the impact of interest rate rise occurs, house prices decrease by 0.302% at the state of real debt dynamics and collateral effect, but 0.359% at the state of nominal debt dynamics and collateral effect. This implies that as the leverage based on the collateral value is higher, the impact of interest rate rise by tightening policy grows larger.

[Figure 12] Tightening Policy, GDP, House Price (economic structure with the LTV ratio at 60%)



4. Analysis Limitations

In the DSGE model, variables using aggregate indicators have limitations in explaining the regional effects of housing. The effect analysis in this model focuses on nationwide phenomena of Korea's house price volatility, so if the rising house prices in a certain region is driven by factors specific to the area, not by a national factor, it would not be effective to use interest rates or taxes as a tool for macroeconomic policy.

Joon Hyuk Song (2008) argued that Korea's housing market contains regional specificity, and these specificities of each region and city should be reflected. In other words, given that fiscal and monetary policies are not designed to prevent house prices from becoming overheated in certain areas, these policies should be considered differently from macroeconomic prudence policy, such as the LTV and DTI which intend to affect specific regions and social strata. Indeed, the coupling of house prices

nationwide began tumbling starting 2010, and then house prices in local and capital areas have moved in different direction. And, to say that this phenomenon was driven by either nationwide price factors or regional factor requires an accurate analysis.

The DSGE model in this study has its limitations in recognizing regional specificity in the analysis of individual policy effects. Aggregate data and concepts affecting the entire economic structure were adopted to study each policy, so adding regional effects of late needs to be considered with a caution.

Also, in the DSGE model, the connectivity between house price determinants and economic agents works only by fundamental economic variables, meaning that the house price in this model does not develop into a bubble—overheated housing market. Therefore, all economic agents are made to observe house prices that only follow fundamental economic variables. Putting a bubble into the model is left for future studies to address.

VII. Result Summary and Policy Implications

1. Summary of Results

The central bank adjusts interest rates under the assumption that monetary policy follows the Taylor's Rule. According to simulations, adjusting the nominal interest rate by monetary policy affects both consumption and aggregate production at the same time, causing substantial influences on overall business conditions. A 25bp rise in interest rates causes a fall in consumption by 0.369%. And, the falling consumption in response to the impact of interest rate rise has a house price mechanism operating under it and house mortgage loan placed at its center. The rise in interest rates affects house prices to decelerate and dwindles the size of credit through the mortgage market, thereby increasing the influence of nominal interest rate. As the LTV ratio is raised higher—meaning less regulation, the rise in interest rates causes a larger contraction in aggregate production. To put it another way, monetary policy could serve a significant role in reducing the volatility of the housing market with concurrent impacts on overall business conditions, so decisions on the policy should be made with a caution.

Meanwhile, according to a series of simulations on various economic structure types to see the impacts of tightening policy on the housing market stability, the fall in house prices records -0.294% at the state of real debt dynamics and collateral effects, and it decreases further to -0.364% at the state of nominal debt dynamics and collateral effects. Here, the economic structure used in this simulation is a basic model with real estate taxes at 1% and the LTV ratio at 50%. As part of macroeconomic prudence policy, when the LTV ratio is raised to 55%--meaning less regulation and larger leverage, the impact of interest rate rise turns out to be slightly weak but pulls down

house prices further to -0.368%. This implies that it is the monetary policy that affects the most for the housing market stability, but any decisions on it should be made with a great caution since the policy causes significant impacts on overall business conditions. It is also important to be very cautious when making decisions on changing real estate taxes as well, considering that the increase in taxes from 1% to 3% weakens consumption.

According to the simulation of basic model, the rise in interest rates causes an 8% difference in the house price volatility. It is not easy to find out how consumption and business conditions shift according to changes in macroeconomic prudence policy in the simulation with all conditions unchanged (same conditions for the impact of interest rate rise and real estate taxes). Results does not show that the change in the LTV ratio affects the house price volatility significantly, but still this cannot be overlooked given that the effect of monetary policy magnifies in the economic structure with the higher LTV ratio.

2. Policy Implications

2.1 A Stable housing market comes from Comprehensive Policy Effects

The role of real estate taxes has become increasingly apparent as a policy tool for stabilizing the housing market. Policies on real estate taxes, as well as the monetary policy—addressed in the DSGE model of this study—is a very important instrument affecting overall business conditions. Clearly, the policy agenda of ‘housing market stability’ is not a simple challenge that could be met with the effect of a single policy on real estate taxes. In other words, monetary policy and real estate taxes are policy instruments that affect the overall economy, including consumption and business.

Meanwhile, looking into the changes in the LTV ratio as a tool for macroeconomic prudence policy, reveals that the LTV ratio is directly connected to house mortgage and also to the interest rate for borrowers, thereby setting consumption capacity within inter-temporal budget constraint. Other than that, chancing house prices acts as a fluctuation of collateral value and therefore affects the consumption capacity. A change in the LTV ratio alone does not significantly render the volatility of house prices, so macroeconomic prudence policy through the LTV ratio would serve as an important policy instrument that could lessen impacts on the housing market, only if the market is not overheated. However, if the market is overheated and house prices need to be stabilized, it would be necessary to implement tightening policy by raising interest rates. Given that in the economic structure with a higher LTV ratio monetary policy is likely to bring larger impacts on the housing market, to reach a policy decision would require intensive analysis. It is also important to analyze the effect of monetary policy

as well as housing market, since the policy affects the overall economy including consumption and aggregate production. This study reconfirms that policies on real estate taxes cannot be an elixir for a stabilized housing market because real estate taxes too are connected to consumption and housing market.

This study found that the recent popular topic of normalizing the housing market by cutting the acquisition tax needs to be contemplated with broader policy perspectives. The goal of a housing market stability could be achieved as a product of comprehensive operation of all relevant policies: monetary policy, fiscal policy related to real estate taxes, and macroeconomic prudence policy related to the LTV ratio.

In Korea, real estate tax revenue is closely related to the rise in house price. It is worried that cutting acquisition tax might result in the shortage of local tax revenue, but if the cut is decided in the context of comprehensive policy framework relating to the rise in house price, it is necessary to check out the change in local tax revenue in connection with housing market. However, policies on real estate taxes must be decided with medium- and long-term perspectives, considering policy consistency and market predictability enhancement. Any temporary fiscal policy related to the housing market is highly like to undermine the credibility of policy, heighten the volatility of the housing market, and eventually move away from the goal of stabilizing the housing market to an entirely different direction.

2.2 Flexible Management of Macroeconomic Prudence Policy and Housing Finance Inclusion

In the housing financial market, mostly Seoul and Gyeonggi province have long been the target of the LTV regulation, meaning that the LTV ratio has been used as the strongest instrument of macroeconomic prudence policy to curb speculative housing demand. Now is the time to conduct an analysis to see whether the LTV ratio of Korea today is overly low to help achieve the goal of housing market stability.

This study found that a change in the LTV ratio does affect the volatility of the housing market, but the size of the change in the LTV ratio (from 50% to 55%) does not seem to cause an equal corresponding size of impact on the housing market volatility. In this regard, severe LTV regulation as today might exploit financial inclusion of low-income age groups in the housing market.

Korea’s average LTV ratio is very low, compared to other major advanced economies, implying a heavy regulative policy for macroeconomic prudence under operation. But, comparing Korea’s average LTV ratio with other countries might need to reflect the Chonsei system unique in Korea.

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