GBM based Policy Influence Analysis of Agent Simulation Parameters

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***Abstract*—In this paper, GBM(generalized boosting model) based policy influence analysis is presented for house market agent simulation. In order to execute the agent simulation, various simulation parameters must be set. Among the parameters to be set, there are policy parameters that affect the policy goal, which is the main result of the simulation. Therefore, if simulation is executed by setting policy parameters variously, the results of simulation may be different. Simulation is usually performed by combining policy parameters based on policy objectives and then the result is analyzed whether the simulation result meets policy goals or not. However, it is difficult to analyze what kind of policy parameters affect policy objectives among policy parameters. In this paper, in order to analyze how the policy parameters affect policy goals, we set policy parameters in various combinations, and then execute social phenomenon agent simulations, and then analyze the impact of policy parameters using GBM algorithm.**

Keywords— Policy parameters, policy influence analysis, agent simulation.

I. INTRODUCTION

ABM (Agent Based Model) simulation is mainly proposed in population model simulation [1,2], and simulation results may be different depending on the setting of simulation parameters. To perform the agent simulation, we design an agent simulation model, implement key parameters in the simulation model, set appropriate values for the main parameters, and run the simulation. The simulation results may vary depending on the set values of the simulation parameters. Among the parameters to be set, there are policy parameters that affect the policy goal, which is the main result of the simulation. Therefore, if the simulation is performed by setting various policy parameters, the result of the simulation may be different. Although there are simulation applications that fix the policy parameters and execute the simulation and then analyze the results, the simulation user who determines the policy must analyze what values of the policy parameters should be set in order to obtain the desired simulation result(policy goal). When a policy maker performs a simulation to determine a policy, it may be helpful to set the value of policy parameters for simulation execution if the impact of policy parameters is analyzed according to policy goals. When simulation is run a policy by combining policy parameters based on policy goals, the results of the simulation can be used to analyze whether policy goals are met. However, it is difficult to analyze what kind of policy parameters affect policy objectives among a plurality of policy parameters. In this paper, we analyze the impact of policy parameters on policy objective by conducting social phenomenon agent simulation. Policy parameters should be set in various combinations to analyze what kind of policy parameters have influence on policy objectives.

The rest of the paper is organized as follows. Section II describes policy goals and policy parameters, while Section III describes the policy parameter impact analysis. Some concluding remarks are finally given in Section IV.

II. POLICY GOALS AND POLICY PARAMETERS

There are various simulations to simulate social phenomena, and each simulation understands social phenomena and predicts the future. There may be a housing simulation model to simulate the social phenomenon of the housing market, and a simulation can be performed to predict the housing price [3]. One of the reasons that policy maker performs housing market simulation may be the policy goal of housing price stability. There are many parameters in the housing market simulation model, and among them there are key parameters such as loan and interest which are closely related to house price.

We analyzed the effects of taxation and monetary policy on the housing market in the agent-based housing market simulation model. As a result, the policy parameters related to housing market price is selected loan-to-value (LTV), debt-to-income (DTI), certificate of deposit(CD) interest rate, housing supply ratio, transfer income tax, and holding tax as shown in Table I.

TABLE I. POLICY GOALS AND POLICY PARAMETERS

Policy goals	*Policy parameters*
Housing market stability	- loan-to-value (LTV) - debt-to-income (DTI) - certificate of deposit(CD) interest rate - housing supply ratio - transfer income tax . 1 sector : 12 million won or less . 2 sector : 12 million won ~ 46 million won . 3 sector : 46 million won ~ 88 million won . 4 sector : 88 million won ~ 300 million won . 5 sector : over 300 million won - holding tax . 1 sector : 600 million won or less . 2 sector : 1.2 billion won or less . 3 sector : 5 billion won or less . 4 sector : 9.4 billion won or less . 5 sector : over 9.4 billion won

Loan-to-value ratio(LTV) is the percentage of the amount that a financial institution recognizes against the price of a collateral when making a loan. Debt-to-income ratio (DTI) is the ratio of how much the borrower pays principal and interest for his or her income. CD interest rate is the interest rate applied when CDs are issued and traded in the distribution market. CD is a periodic deposit certificate that can be transferred in the market and is called a certificate of deposit. Transfer income tax is the tax on capital gains due to the transfer of assets. Holding tax(comprehensive real estate tax) is the sum of the total real estate tax for the housing and the comprehensive real estate tax for the land. Among these parameters, transfer income tax and holding tax are divided into 5 sectors each as shown in Table I. Transfer income tax is divided into 12 million won or less(sector 1), 12 million won ~ 46 million won(sector 2), 46 million won ~ 88 million won(sector 3), 88 million won ~ 300 million won(sector 4), and over 300 million won(sector 5). Holding tax is divided into 600 million won or less(sector 1), 1.2 billion won or less(sector 2), 5 billion won or less(sector 3), 9.4 billion won or less(sector 4), and over 9.4 billion won(sector 5).

III. POLICY PARAMETER IMPACT ANALYSIS

Simulation is performed by changing the policy parameters that affect the policy goal of housing market stabilization, and the influence of each policy parameter on the simulation results is analyzed by using the simulation results obtained by changing the policy parameters. The influence of the policy parameters is analyzed by using the generalized boosting model (GBM) proposed in [4]. The GBM algorithm is shown in Fig. 1.

1. Initialization

$$\hat{f}(x) = argmin_{\rho} \sum_{i=1}^{N} L(y_i, \rho)$$

2. Loop (for t = 1,…,T)

[1] compute negative gradient

$$Z_i = -\frac{\partial}{\partial f(x_i)} L(y_i, f(x_i))|_{f(x_i)=\hat{f}(x_i)}$$

[2] randomly select cases from dataset

$(p \times \mathrm{N})$ cases

[3] fit a regression tree

$$g(x) = E(z|x)$$

[4] compute the optimal terminal node predications

$$\rho_k = argmin_{\rho} \sum_{x_i \in S_k} L(y_i, \hat{f}(x_i) + \rho)$$

[5] update $\hat{f}(x)$

$$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \rho_k(x)$$

Fig. 1. GBM algorithm.

where, L is a loss function, T is the number of iterations, K is the depth of each tree, λ is the shrinkage(or learning rate) parameter, p is the subsampling rate.

A. Experiment 1 : LTV, DTI, and housing supply rate

We have performed experiments to analyze the influence of policy parameters using the GBM algorithm. In order to compare the policy influence between LTV, DTI and housing supply ratio in the capital area, LTV and DTI are changed from 0.3 to 0.7 in 0.1 resolution and the housing supply ratio is changed from 0.0005 to 0.0009 in 0.0001 resolution. 125 simulations were conducted to analyze the influence of each policy parameter on the housing price index in capital area. The simulation results are shown in Fig. 2 which shows only 6 results among 125 results. According to policy parameters, the simulation results are different.

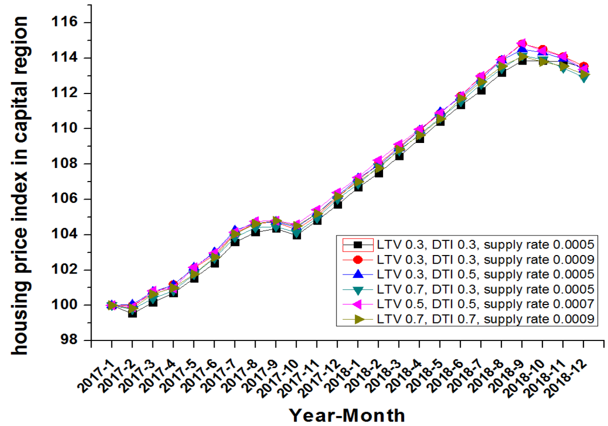

Fig. 2. Simulation results : housing price index in capital area.

For the non-capital area, LTV and DTI were changed from 0.3 to 0.7 in 0.1 resolution and the housing supply ratio was changed from 0.0006 to 0.001 in 0.0001 resolution. Therefore, agent simulation was performed 125 times. The simulation results are shown in Fig. 3 which shows only 6 results among 125 results.

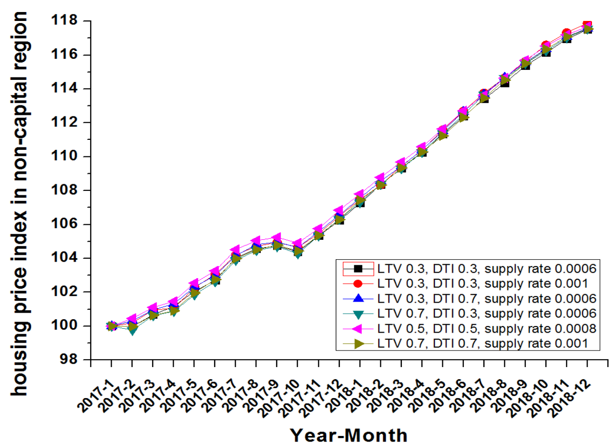

Fig. 3. Simulation results : housing price index in non-capital area.

Using the simulation results, the influence of LTV, DTI and housing supply ratio on the housing price index according to the capital area and the non-capital area is analyzed using GBM algorithm as shown in Table II.

TABLE II. INFLUENCE OF LTV, DTI AND HOUSE SUPPLY RATE ON HOUSE PRICE INDEX

	LTV	*DTI*	*Housing supply rate*
capital area	0.192	0.398	0.41
non-capital area	0.505	0.296	0.199

According to results shown in Table II, LTV had an impact of 0.192, the DTI had an impact of 0.398, and the housing supply ratio had an impact of 0.41 in capital area. DTI and housing supply ratio have more influence on housing price index of capital area than LTV. LTV was 0.505, DTI had an impact of 0.296, and housing supply ratio was 0.199 in non-capital area. In non-capital area, LTV was analyzed to have more influence on policy objectives. In the case of the housing price index, the capital area is affected by the housing supply ratio and the non-capital area is affected by the LTV.

B. Experiment 2 :5 sectors of transfer income tax

We have compared the policy(housing lease index) influence from sector 1 to sector 5 of transfer income tax in capital area and non-capital area. In order to compare the impacts on the policy goals by the transfer income tax sectors, the sector 1 is changed from 0.04 to 0.08 in 0.02 resolution, the sector 2 is changed from 0.13 to 0.17 in 0.02 resolution, the sector 3 is changed from 0.22 to 0.26 in 0.01 resolution, the sector 4 is changed from 0.33 to 0.37 in 0.01 resolution, and the sector 5 is changed from 0.36 to 0.4 in 0.02 resolution. Therefore, agent simulations are performed for a total of 675 combinations. The simulation results in capital are shown in Fig. 4 which shows only 6 results among 675 results.

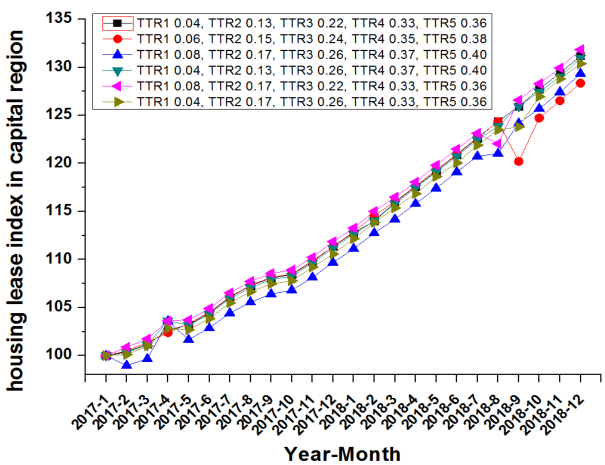

Fig. 4. Simulation results : housing lease index in capital area.

The simulation results in non-capital are shown in Fig. 5 which shows only 6 results among 675 results.

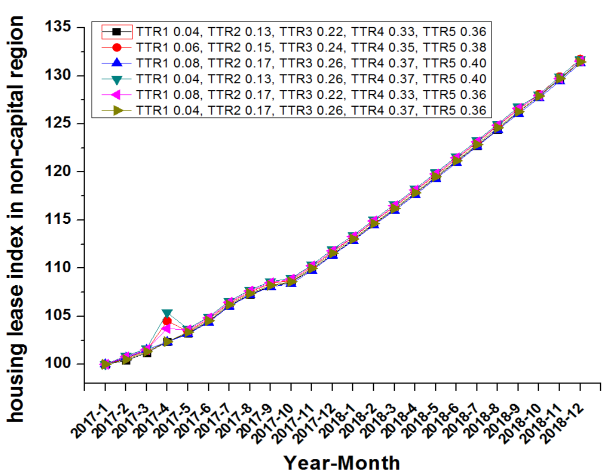

Fig. 5. Simulation results : housing lease index in non-capital area.

Using the simulation results, the influence from sector 1 to sector 5 of transfer income tax on the housing lease index in the capital area and the non-capital area is analyzed using GBM algorithm as shown in Table III.

TABLE III. INFLUENCE OF TRANSFER INCOME TAX SECTORS ON HOUSE LEASE INDEX

	Sector 1	*Sector 2*	*Sector 3*	*Sector 4*	*Sector 5*
capital area	0. 195	0.202	0.161	0.273	0.169
non-capital area	0.165	0.370	0.207	0.176	0.082

In the case of the capital area, the influence of sector 1 is 0.195, the sector 2 has an influence of 0.202, the section 3 has an influence of 0.161, the section 4 has an influence of 0.272, the sector 5 has an impact of 0.169, It is analyzed that the sector 4 in which transfer income is between 88 million won and 300 million won has the greatest impact on the housing lease index in capital area. In the case of the non-capital area, the influence of sector 1 is 0.165, the influence of sector 2 is 0.370, the influence of sector 3 is 0.207, the influence of sector 4 is 0.176, and the effect of sector 5 is 0.082. It is analyzed that the sector 2 in which transfer income is between 12 million won and 46 million won has the greatest impact on the housing lease index in non-capital area. Therefore, in the case of the housing lease index, the non-capital region is more affected by the lower amount of transfer income than the capital region.

IV. CONCLUSIONS

Among the parameters for performing the agent simulation, there are the policy parameters that affect the policy goal, which is the main result of the simulation. If the impact of key policy parameters on policy objectives is analyzed, it may be helpful for policy makers to design policies. In this paper, we analyze how the policy parameters such as LTV, DTI, housing supply ratio, and transfer income tax affect housing price index and lease index in capital and non-capital area using GBM algorithm. In the future, it may seem necessary to analyze not only the relative influence of policy parameters on policy objectives, but also their absolute impact.

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