Objectivity based Self-Evolving Agent Model Validation for Social Issue Simulation

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***Abstract*—In this paper, objectivity based self-evolving agent model validation is presented for house market simulation. The self-evolving simulation updates agent models using verification data. However, because there is no verification data for the future, it is difficult to predict the future with self-evolving module accurately. Therefore, even if simulation is performed using a self-evolving mechanism, validation of the agent model is still important in order to obtain correct prediction results for the future. Verification of objectivity is carried out in the procedure of comparing the simulation prediction value with the past actual data, and it is judged that the result of the simulation is valid if it shows a form similar to the past actual data. The error rate and correlation between the verification data and simulation results are calculated through the root mean square error (RMSE), mean absolute percentage error (MAPE), and coefficient of determination. The accuracy of the simulation results for the apartment price index and 2-year-lease index are approximately 95% and 89%, respectively, and coefficient of determination are 0.507 and 0.753, respectively. Therefore, self-evolving agent based model designed for house market simulation can be said to have objectivity.**

Keywords—agent simulation, model validation, objectivity of validation.

I. INTRODUCTION

A great part of earlier researches in the ABM field have been proposed in dynamic demography [1-2]. Generally, the structure and parameters of the ABM model cannot be autonomously evolved. Therefore, running long-term simulations will accumulate simulation errors over time. Therefore, the self-evolutionary agent-based simulation framework to reduce long-term simulation errors is proposed [3] and the component based agent simulation modeling for self-evolving house market simulation was proposed [4]. The self-evolving simulation updates agent models using verification data. However, because there is no verification data for the future, it is difficult to predict the future accurately. Therefore, even if simulation is performed using a self-evolving mechanism, validation of the agent model is still important in order to obtain correct prediction results for the future. The validation of the model is based on objectivity. This paper propose the objectivity based agent model validation for housing market ABM simulation. To see if the model for self-evolution has objectivity, this paper analyzes the error and correlation between the simulation results and the verification data after executing the housing market ABM simulation without the self-evolution module .

The rest of the paper is organized as follows. Section II describes self-evolving agent based simulation framework and modeling, while Section III describes the agent model validation. In Section IV, we provide the result of our experiments. Some concluding remarks are finally given in Section V.

II. SELF-EVOLVING AGENT BASED SIMULATION

Long-term simulation may be inaccurate the error between verification data and simulation results. The previous research is proposed to solve this problem using a self-evolving simulation [3, 4].

A. Self-evolving Agent based Simulation Framework

According to [3], the change recognition module predicts and detects that the difference between the actual data and the simulation result exceeds the threshold value. The model evolution module makes a strategy for autonomously developing current model. The ABM reconstruction module changes model parameters and structure according to the model evolving strategy.

B. Component based Agent Simulation Modeling

According to [4], agents consists of house holder, external supplier, and bank. These agents interact with one another and environment, such as house market and house. The roles of house holder, external supplier, and bank are shown in Table I.

TABLE I. ROLES OF AGENTS FOR HOUSE MARKET SIMULATION

Agent	***Roles in House Market Simulation***
House Holder	- List houses for sale and rental - Purchase and rent a house - Contract with other agent - Receive information from environment - Request a loan to the bank
External Supplier	- Demolish the existing house - Build and list the new house - Processe the contract - Receive information from environment
Bank	- Give loan to the agent

Agent model should be componentized to reconfigure the agent model. Components have a hierarchical structure, such as atomic and coupled model.

III. AGENT MODEL VALIDATION

The designed self-evolving ABM model for house market simulation should be verified the validity of the model for prediction accuracy. Verification of the objectivity is a process of giving objectivity to the user in the process of expressing the model to fit the essence of the problem. In general, verification of objectivity is carried out in the procedure of comparing the simulation prediction value with the past actual data, and it is judged that the result of the simulation is valid if it shows a form similar to the past actual data.

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To verify the validation of the simulation results without self-evolution, the error rate and correlation is calculated through the root mean square error (RMSE), mean absolute percentage error (MAPE), and coefficient of determination.

1) RMSE: The RMSE for the simulation results is given by (1).

$$RMSE = \sqrt{\frac{\sum_{t=1}^{T}(z_t^{*}-z_t)^2}{T}} \quad (1)$$

where T is the last step number, z_t^{*} is the simulation result at step t, z_t is the verification data at step t.

2) MAPE: The MAPE for the simulation results is given by (2).

$$MAPE = \frac{100}{T}\sum_{t=1}^{T}\left|\frac{z_t^{*}-z_t}{z_t}\right| \quad (2)$$

where T is the last step number, z_t^{*} is the simulation result at step t, z_t is the verification data at step t.

The smaller the RMSE and MAPE values are, the less the difference between the simulation result and the verification data is. Therefore, the simulation model is valid when RMSE and MAPE have small values.

3) Coefficient of determination : The larger the coefficient of determination (R^2) between the simulation results and verification data, the more correlation is. The coefficient of determination is given by (3).

$$R^2 = \frac{(\sum_{t=1}^{T}(y_t-\bar{y})(\hat{y}_t-\bar{\hat{y}}\ ))^2}{\sum_{t=1}^{T}(y_t-\bar{y})^2 \times \sum_{t=1}^{T}(\hat{y}_t-\bar{\hat{y}}\ )^2} \quad (3)$$

where T is the last step number, y_t is the verification data at step t, and $\hat{y}_t$ is simulation result at step t, and $\bar{y}$ is the average of the verification data, $\bar{\hat{y}}$ is the average of simulation result.

IV. Experiment

In order to verify the validation of developed housing market ABM, we run the housing market ABM simulation using the discrete event system specification (DEVS) C++ engine. We use Intel(R) Xeon(R) CPU E5-2697 @ 2.3GHz and 792GB RAM as a simulation server.

As initial data, 1,000 agents were generated by household finance welfare survey data (2015 year) of the statistics in Republic of Korea. From January 2015 to December 2016, a simulation of 24 months is executed.

A. Apartment Price Index in Metropolitan area

The simulation is run 20 times under the same conditions and the results for the apartment price index in metropolitan area were compared with the verification data. The verification data are the real apartment price index of metropolitan area extracted from the website of Ministry of Land, Infrastructure and Transport in Republic of Korea.

The simulation results comparison and RMSE & MAPE of simulation results are shown in Figs. 1 and 2, respectively. As shown in Fig. 1, the difference between simulation results and verification data is increased over time. However, the trend of simulation results follows the verification data.

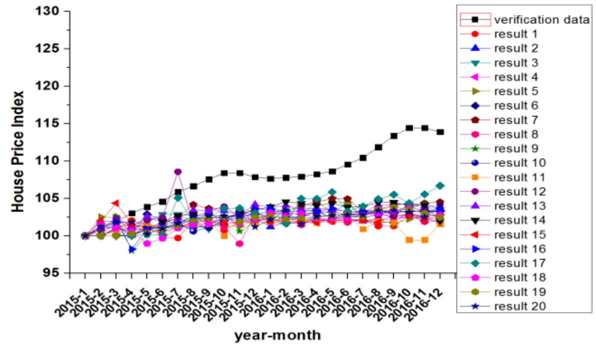

Fig. 1. Simulation results comparison with respect to apartment price index in metropolitan area.

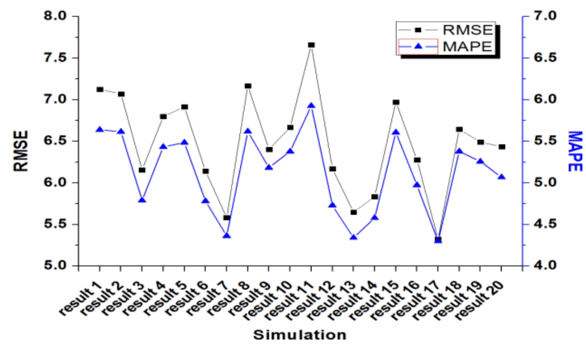

Fig. 2. RMSE and MAPE of apartment price index in metropolitan area.

As shown in Fig. 2, RMSE of simulation results is between 5.32 and 7.66 and the average RMSE is 6.48. MAPE of simulation results is between 4.3 and 5.93 and the average MAPE is 5.12. Therefore, the mean error and accuracy for entire simulation steps is approximately 5% and 95%, respectively. As shown in Fig. 3, the coefficient of determination is small when the MAPE value is large, and is large when the MAPE value is small. Coefficient of determination of simulation results and verification data is between 0.006 and 0.841 and the average is 0.507. There is correlation between simulation results and verification data.

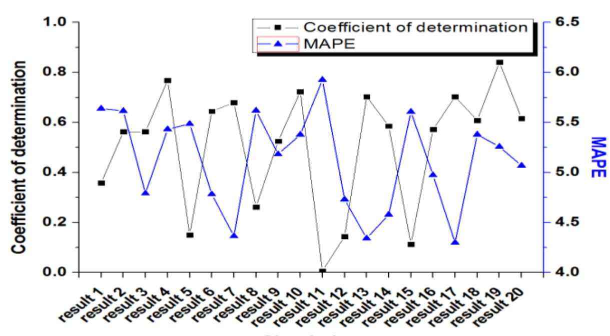

Fig. 3. Coefficient of determination and MAPE of apartment price index in metropolitan area.

B. Apartment 2-year-lease Index in Metropolitan area

The simulation is run 20 times under the same conditions and the results for the apartment 2-year-lease index in metropolitan area were compared with the verification data. The verification data are the real apartment 2-year-lease index of metropolitan area extracted from the website of

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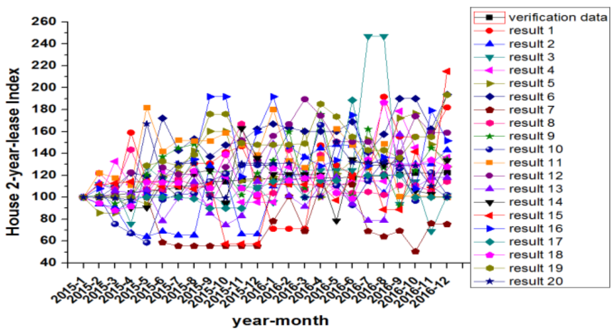
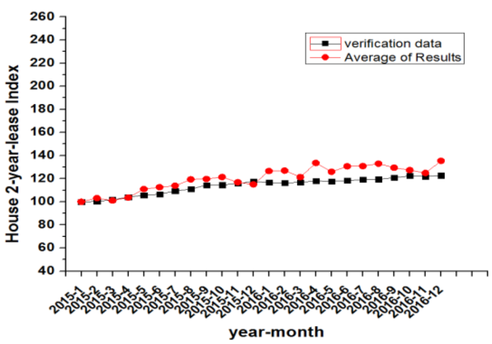
Ministry of Land, Infrastructure and Transport in Republic of Korea.



(a)



(b)

Fig. 4. Simulation results comparison with respect to apartment 2-year-lease index in metropolitan area. (a) comparison 20 simulation results with verification data (b) comparison average of 20 simulation results with verification data.

The simulation results comparison is shown in Fig. 4. As shown in Fig. 4(a), it is hard to find the relations between simulation results and verification data over time. Therefore, as shown in Fig. 4(b), average of simulation results from 1 to 20 is compared with verification data. The trend of average of simulation results follows the verification data.

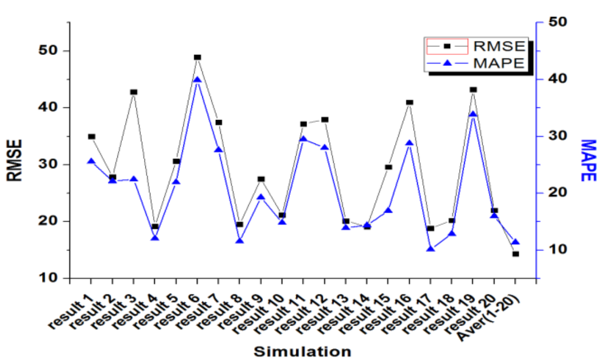


Fig. 5. RMSE and MAPE of apartment 2-year-lease index in metropolitan area.

As shown in Fig. 5, RMSE of simulation results is between 18.83 and 48.95 and MAPE of simulation results is between 10.15 and 39.91. There are high errors in these simulation results. However, the average simulation results has RMSE and MAPE of 14.36 and 11.37, respectively. Therefore, the mean error and accuracy using average simulation is approximately 11% and 89%, respectively. As shown in Fig. 6, coefficient of determination of simulation results and verification data is between 0.007 and 0.705. The simulation results shows coefficient of determination value of large deviation. However, coefficient of determination of average simulation is 0.753. Therefore, there is correlation between average simulation results and verification data.

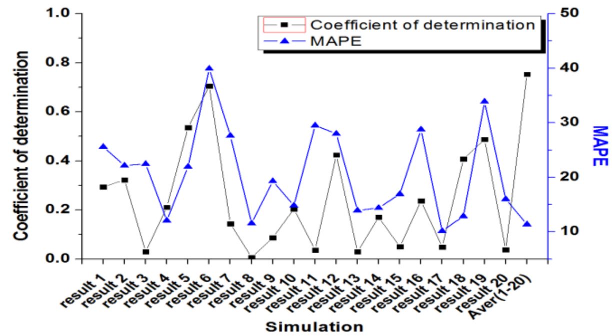


Fig. 6. Coefficient of determination and MAPE of apartment 2-year-lease index in metropolitan area.

V. Conclustions

Validation of the agent model is still important in order to obtain correct prediction results for the future, even though simulation is performed using a self-evolving mechanism,. In order to verify the validation of developed housing market ABM, we run the housing market ABM simulation and analyze the objectivity of the model.

When comparing the results for the apartment price index of metropolitan area with the verification data, the accuracy of the simulation results and the coefficient of determination are approximately 95% and 0.507, respectively. When comparing the result of the metropolitan apartment 2-year-lease index with the verification data, the accuracy of simulation result and the coefficient of determination are approximately 89% and 0.753, respectively, when using the average simulation. Therefore, the simulation model has objectivity with respect to the apartment price index and 2-year-lease index in metropolitan area.

Acknowledgment

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