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Development of an Overseas Real Estate Valuation Model Considering Changes in Population Structure*

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Abstract

Purpose - Aging and fewer economically active people have challenged the assumption of continuous population increases. A new real estate valuation methodology reflecting changes in population structure is thus needed.

Research design, data, and methodology - The relationship between demographic change and changes in real estate prices is analyzed using ordinary least squares (OLS) to estimate the parameters, and a population structure change (PSC)-Binomial Option Model is developed to assess the volatility of the estimated parameters. Results based on Seoul and Shanghai data are compared.

Results - Results of the DCF method indicate that investing in Seoul is better than investing in Shanghai, but the binomial option indicates the opposite. The PSC-binomial option model, reflecting changes in population structure, yields higher values (24.6 million won in Seoul and 43.3 million won in Shanghai) than those given by the binomial option model.

Conclusions - This study indicates that applying changes in population structure to existing research, such as in the binomial option model, represents a more accurate real estate valuation method. Results demonstrate that the new model is more accurate than existing models such as the DCF or binomial option.

Keywords: Overseas Real Estate, Changes in the Population Structure, Real Option Model, Valuation.

JEL Classifications: R31, R32, C14.

1. Introduction

More people have recently begun to consider making foreign real estate investments to obtain safer or higher returns because of the increased uncertainty of the stock markets and the decline in real estate prices, exacerbated by the low interest rates in international markets and the global economic crisis. Interest in real estate investment in developing countries is increasing due to the expectation to profit from relatively high real estate prices felt by the rich in developed countries (Noorbakhsh et al., 2001). Global funds have moved to the real estate markets in developing regions such as China, Southeast Asia, and India, and their prices have steadily trended upwards (Jiang et al., 1998).

Since many elements such as the exchange rates and the relevant data about the target regions, must be considered in foreign investment decisions, they are difficult for investors to make. In order to assist decision-making, various methods have been studied. There are also many methods of evaluating the future value of real estate because of the uncertainty involved and the many economic variables affecting real estate investments.

Value assessment considers the underlying value of the tangible and intangible property being considered for investment and measures its value at a specific future time. Most studies on the value assessments of real estate have been performed during research devoted to assessments of R&D projects or the real estate investments of companies. However, there are differences between the personal value assessment of real estate and the corporate value assessment of R&D projects or stocks.

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Personal investments in real estate used to be difficult because of the cost, time, and professional knowledge required. Now, however, private investment decisions require little research; knowledge gained through the Internet and offline lectures often suffices. A number of studies have been conducted to help investors in their private real estate investments.

Assessments of real estate valuation have been performed using several methods such as the discounted cash flow (DCF) and real option model, which employ various macroscopic and microscopic economic indicators. However, studies that consider changes in the population structure as an important factor are very rare. Populations in developing countries are increasing steeply, and full urbanization is not a reality yet. In developed countries, real estate prices are declining, the population of economically active people is decreasing and urbanization is over 90%. We can thus assume a relationship among demographic changes, urbanization ratios and the real estate prices (Engelhardt & Poterba, 1991; Capozza et al., 2002; Zhu, 2006; Ryu & Lee, 2012). Recent studies report that demographic changes and real estate prices have a close correlation and that population reductions cause real estate prices to fall (Quigley, 1999; Kim, 2000). For example, Changes to the population structures of Japan and Spain have reduced their real estate prices (Noguchi & David, 2008).

Most studies on the valuation of real estate have assumed an increase in population. Assumptions that recent population decreases and the aged in developed countries increase have brought into question. As Korea’s population is expected to soon fall, and that as China’s will also be reduced within 10 years, a study on the value estimation of real estate that consider this downward trend is needed. This study presents a new methodology for the systematic evaluation of real estate value that considers current demographic changes.

The DCF method, the classic way to evaluate real estate value has been the most common method. However, the variables affecting the value of the investment alternatives in this method are finalized at the time of the investment, and as it is assumed that the variables do not change over time, the DCF does not reflect the volatility of risk. The real option theory was proposed in response to many scholars insistence that future uncertainty and environmental changes had to be considered (Yeo & Qiu, 2003).

Studies on real options, argue that the binomial options model is the best investment valuation method (Smit & Ankum, 1993; Michailidis & Mattas, 2007). As the binary option allows an understanding of the principles by which to evaluate option pricing without complex mathematical techniques, it is appropriate for use with real estate valuation models and the value assessment of complex derivatives.

Gu et al. (2014) suggested the real estate valuation model taking into account the population structure. In that study, performances comparison between the proposed model and binomial option model has been done based on the Korean domestic environments. So it requires to study considering the different population structure changes of foreign countries to verify the model to be more valuable in estimating the future values. So, this study extends the model to be useful for the overseas real estate investments.

This study argues that a method employing the real option that considers changes in population structure is the most accurate way of evaluating real estate. This study uses data on population structure changes and real estate prices drawn from the People's Republic of China and the Republic of Korea. Parameters estimated from an OLS analysis are used for real options, and 'population structure change-binomial option model' (after the “PSC-binomial option model”) is developed. To verify this model, a valuation test is conducted using real data based on projections concerning the People's Republic of China and the Republic of Korea.

Chapter 2 reviews extant literature on real estate investment methods, the binomial options model, and the relationship between population structure changes and real estate prices. Chapter 3 describes the PSC-binomial option model design, reflecting demographic changes, for overseas property valuations. Chapter 4 describes the case studies about real valuations of real estate in the People's Republic of China and the Republic of Korea using both the proposed model and the existing binary option model and then compares their results. Finally chapter 5 summarizes the research results and discusses the significance and limits of this study.

2. Literature review

2.1. Real option real estate valuation

There are many methods of valuating real estate, such as the cash flow method, discounted return on Investment, return on equity, average rate of return, payback period, capitalization rate, internal rate of leverage effect, return, and net present value methods. The real option method has become a common way to overcome the shortcomings of the other methods, the gravest of which is that, as the variables affecting investment are finalized at the time of investment, their volatility cannot be reflected in the models. The real options is thus used to evaluate real estate values more accurately by considering the uncertainty embedded in investment decisions.

Most assessments of the real value of real estate using the real option focus on company investments, few focus on private investors. Shen et al. (2013) developed a decision-making model that considers delays in budget execution based on the real option, concept that can be used to evaluate the value of projects and determine their required development time. Sabour et al. (1999) suggested a mine investment decision model using the option pricing and dynamic programming models, by which the total revenue of a company can be estimated by dynamically considering both the company's annual growth and the mining costs. Bulan et al. (2009) analyzed the correlation between investment delay and competition based on data drawn from Vancouver, Canada covering 1979 to 1998. The results showed that risks increased during that time.

2.2. Demographic changes and real estate price

Variables such as business cycle, macroeconomic factors, monetary policy, and population structure are usually used to determine real estate prices. Among these, population structure is most important. In the United States, the proportion of the population aged 40 to 59 has fallen since 2007, while housing prices have plummeted and (U.S. Census Bureau, 2013); in Japan the percentage of the population aged 40 to 59 was also falling in 1993 (Statistics Bureau Japan, 2013). The proportion of Korea's population aged 40 to 59 and the nation's real estate prices are both predicted to begin decreasing in 2017 (Statistics Korea, 2013).

The global population of economically active people, including that of Korea, is predicted to begin decreasing soon due to low birth rates and an aging population demographic changes that will have a significant impact on property prices. In a study on the relationship between real estate prices and demographic changes focusing on Japan and Spain, Harry Dent proved that the rate of demographic changes and urbanization have an impact on declining real estate prices (Harry, 2011). Kabisch & Grossmann (2013) analyzed the relationship between demographic changes due to aging and low birth rates and real estate prices in Eastern Germany. They showed that the sudden declines revealed by the research did not affect real estate prices. Xili et al. (2012) suggested a positive impact between population growth rates and real estate prices of Jilin City in People's Republic of China. Xu (2010) used a mixed model to analyze the relationship between housing prices and the elderly; their results showed that an increase in the elderly population had a significant effect on the decline of real estate prices.

Thus demographic changes have an effect on real estate prices. Current studies are interested merely in the relationship between demographic changes and changes in real estate prices, however. No study has yet analyzed real estate valuation by considering demographic changes.

2.3. Real option

The real options pricing model is applied to the valuation of real property assets being sold by businesses or being used as investments during a business expansion or change; it is also applied to delayed investments. The real options concept originated in the Black-Sholes option pricing model developed by Black & Sholes (1973), which systematically analyzed and formalized option pricing. Applying these options to real assets in the financial sector began when Myers (1997) applied them to capital budgets and R&D in resource distribution. The binomial option pricing model developed by Cox et al. (1979), provides investors with a sound understanding of pricing principles, does not require complex mathematical techniques, and can be easily applied to the evaluation of complex derivatives; the model thus became prevalent in many fields.

As mentioned, real options are comprised of delay, expansion, reduction, cancel and change in investment, and providing flexibility. The real options model avoids the shortcomings of the cash flow discounting method (DCF) model, and can be regarded as a combination of the DCF and real option values concept. The real options approach can be formulated as shown below.

Expanded NPV = Static NPV + Option Premium

where, Expanded NPV = worth of the investment alternative through real options

Static NPV = worth of the investment alternative through the DCF model

Option Premium = worth of flexibility due to the investment option.

In other words, the real options method provides a decision-making framework with none of the drawbacks of the traditional NPV method and that considers investment the flexibility. Therefore, the real options valuation method provides more valuations of investment alternatives, thus increasing the possibility of profit increases and reducing the risk of loss.

The definition of "real options" varies among scholars. Amram & Kulatilaka (1999) classified the options into operation, investment, contract guarantee options, while Trigeorgis (1999) classified the real options into delay, stepwise investment, change of size, cancel, transition, growth and complex linkage options. The real options model can be divided into the Black-Scholes and binary lattice models. The former consists of a non-risk portfolio and is based on the logic of the price earning rate with a non-risk interest. The binomial lattice model operates on the assumption that the price fluctuations of a base property follows a binomial distribution and have only two possibilities, either an increase or a decline. The Black-Scholes model is considered a continuous model because of the continuity in its assessment of time, while the binomial lattice model is considered as discrete model because it assumes an increase or a decline are the only possibilities.

3. Methodology

3.1. Design for research

This study, establishes a real estate investment strategy that considers changes in population structure and then compares it to overseas investment alternatives using the process described below. First, to compare investment alternatives, Seoul and Shanghai data on population structure and real estate price changes were extracted. Second, after examining the changes among the cities productive population, data on demographic and real estate price change were converted into changes in the year-on-year growth rate. Third, the correlation between changes in demographics and the real estate price growth rate were be examined by analyzing the correlations between the changes in the cities' population structures and the growth rates of their real estate prices. Fourth, the parameters affecting real estate prices were estimated along with changes in the population structures through OLS analysis, and a PSC-binomial option model was designed. Fifth, the value of each city's real estate was calculated and an investment alternative selected through the DCF and binomial options model. Finally, the value of the real estate was calculated and an investment alternative selected through the PSC-binomial option in a comparison with the results produced by the traditional model. The changes in population structure and real estate values in Seoul and Shanghai cover from 1987 to 2012; decision-making occurs on the assumption that the real estate was purchased in 2012 and will be sold seven years afterwards.

3.2. The population structure reflects the parametric elicitation

The year-on-year data on the production population (aged 15 – to 64) of Seoul and Shanghai covering 1987 to 2012 were extracted from the Korea National Statistical Office and People's Republic of China to find the parameters reflecting the population structures. Annual production possible population is used in this research because it has not only been used mainly in analyzing the micro-economy and macro economy, but also the changes in the population structure gives a close impact on the economic strength of the country in the future. For an exponentiation of the changes in population structure, the number of economically active people in year n-1 was divided into the number of economically active people in year n-1. The real estate indices were obtained by measuring the changes in the exponentiation of the population structure with data from Housing Purchase Price Composite Indices (HPPCI) and the China real estate index system (CREIS) from 1994 to 2009 (KB Bank Composite index of home sales price, 2013; China real estate index system, 2013).

If the changes in the population structures are related to changes in real estate prices, a meaningful correlation could be derived. First, for Seoul, an analysis of the graph shows that the change in the population structure precedes the change in housing prices by a year. Thus, a correlation between n+1 values of population growth rate and the growth rate of housing prices is observed.

For Shanghai, the correlation in n year is observed because the re is no time-gap between the growth in population and the growth in housing prices. There is a positive correlation between growth in population and growth in housing prices in both Seoul and Shanghai ($p<0.05$), a shown Table 1.

<Table 1> Correlation between population growth and growth in home prices

Variables	Coefficient	p-value
Population growth rate & growth rate of housing price (Seoul)	.474	.014
Population growth rate & growth rate of housing price (Shanghai)	.596	.019

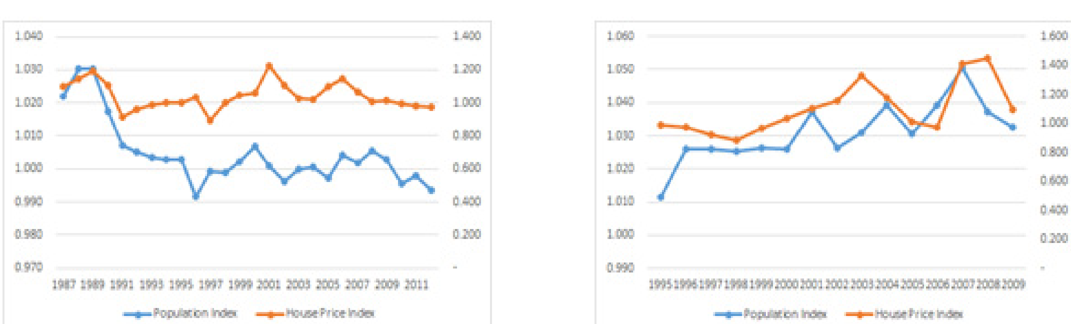
The above results, were used to estimate the parameters of the growth in population and housing prices, through an OLS analysis, as shown in Table 2. The parameters derived, can be used to predict real estate values.

<Table 2> Results of parameters estimation

Classification	Seoul (=.225)				Shanghai (=.355)			
	Non standardized coefficient	S.E	T	p-value	Non standardized coefficient	S.E	T	p-value
Constant	-2.837	1.471	-1.929	.066	-10.994	4.517	-2.434	.030
Population growth rate	3.864	1.464	2.638	.014	11.730	4.381	2.677	.019

3.3. Binomial options model for real estate valuation

This section evaluates the investment value of real estate using the real options method. Though the Black-Scholes model, with its continuous-time, can be applied to real estate investing,



Seoul Shanghai

<Figure 1> Changes in the population structures and house prices graph for Seoul and Shanghai

the binomial options model will be used because it is closer to the American options. The option value calculation method in the binomial options model uses the risk-neutral probability approach, which calculates the option value by assessing the probability of increases and decreases based on the current value of the underlying asset. The risk-neutral probability approach adjusts the risk of future cash flows using non-risk interest rate and the risk-neutral probability, and the binary models is developed by calculating the probability of upward and downward volatility in the underlying assets. The upward volatility u and the down ward volatility d are calculated by Equation 1, and the risk neutral probability p is calculated as shown in Equation 2.

Rise volatility $u = e^{(\sigma \cdot \sqrt{\delta^t})}$

Decline volatility $d = e^{(-\sigma \cdot \sqrt{\delta^t})}$ (Equation 1)

where, σ = volatility, δ^t = time interval (1 year)

$$p = \frac{(e^{(r^f \cdot \delta^t)} - d)}{(u - d)}$$ (Equation 2)

where, r^f = Non-risk interest rate

Through Equation 1 and 2, the binomial model can be deployed in grid form and the value of the option on each node can be calculated through Equation 3.

$$C_n = (p \cdot SU^n + (1-p) \cdot SD^n) \cdot e^{-r \cdot \delta^t}$$ (Equation 3)

where, C_n = the option value of node n

p = Risk-neutral probability, δ= Non-risk interest rate

SU^n = the asset value with rise probability of node n

SD^n = the asset value with decline probability of node n

3.4. Binomial options model reflecting the structure of the population in real estate valuation

This study uses the PSC-binomial option model, which considers changes in population structure. Although the existing binomial option calculates both upward and downward volatility, the calculation method does not consider changes in population structure because only the upward volatility of housing prices is considered. Furthermore, this volatility is calculated only during a period of population increase, on the assumption that the population is always increasing. However, calculations of real estate values must assume a future population decline and thus a changed population structure. Therefore, Equation 4 modifies volatility of Equation 1 and substitutes the calculated parameters.

Upward volatility $u = e^{(x_n - 1) \cdot \sqrt{\delta^t}}$

Downward volatility $d = e^{(-x_n - 1) \cdot \sqrt{\delta^t}}$ (Equation 4)

Where, x_n = OLS compares the number of economically active people & real estate prices in year n.

4. Analysis and Results

4.1. The investment evaluation of real estate using DCF

4.1.1. Overview

This study considers actual real estate investment made in the real estate markets of the People's Republic of China and the Republic of Korea, specifically Shanghai and Seoul, which were chosen because they are economic capitals with similar economic levels. A research overview and the assumptions made about the cases are shown in Table 3.

This study assumes that two real estate investment alternatives were considered in each city in January 2013 based on data covering year 2000 to 2012 and that the funds available total 10 billion won, including a bank loan of 5 billion. The loan's interest rate is 4.84% (based on new household loan data drawn from the Central Bank's economic statistics system in January 2013), and the present discount rate was calculated at an average inflation rate of 2.70% from 2001 to 2012. If more than 10 year investment period is used, the results will be highly affected by the uncertainty of the prediction of changes in the population structure, while less than five year investment period is used, it is very difficult to reflect the impact by the changes of population structure and the long-term characteristics of real estate investment. Therefore, the total investment period was set as 7 years.

<Table 3> Basic research data

Classification	Korea	China
Investment Period	7 Years	
Area	Seoul	Shanghai
Data Analysis Period	Analysis: 2000. 01. 01. - 2012. 12. 31. Investment: 2013. 01. 01. - 2022. 12. 31.	
Investment Cost	10 billion won (with lone : 5biillion won)	
Loan Interest Rate	4.84%	
Present Discount Rate	2.70%	
Monthly Rental Profit	3,000,000	1,500,000
Acquisition Tax	4% of Price	0.4% of Price
Acquisition Expense	1.5% of Price	1% of Price
Depreciation Rate	3.3% of Price	
Management Expense	(Annual profit – Financial Charge)*5%	0.1%

4.1.2. NPV analysis utilizing DCF

First, the NPV for each real estate investment in China and Korea is analyzed prior to analyzing the new binomial options model applying the changes in population structure; this procedure produces the basic data for the option value assessment measuring the valuation difference between the traditional model and the binomial options model. Table 4 and 5 show the results of the cash flow and NPV as calculated using the investment cost, financial expenses, operating revenue, rental and sale revenues during the operation period in Seoul and Shanghai. It is assumed that the sales revenue for real estate is determined as the purchase price, based on the minimum revenue assumption, because although sale prices may fall, they have continued to rise; in fact, bilateral real estate prices rose from 2000 to 2012. Costs such as the anesthetic/registration tax, acquisition costs, and the administration costs of real estate investment in each country are estimated using statistical data from the Kookmin Bank of Korea and the People's Bank of China.

4.2. Value assessment of real estate valuation using the binary option

4.2.1. Estimation of volatility

The volatility (σ) caused by future uncertainty is estimated in order to calculate the value of an option. Volatility is usually calculated by assessing historical volatility, which can be calculated as shown in Equation 5.

$$\sigma = \sqrt{\frac{\sum_{t=1}^{n}(x_t - m)^2}{n-1}} \quad \text{(Equation 5)}$$

σ: historical volatility, n: total time period, x_t : yield at the time t,

m : the average of yield

The volatility used in the study is calculated based on the changes in housing prices in Seoul and Shanghai, which oc

<Table 4> NPV calculation results for Seoul

(Unit: One million won)

Classification		t=0	t=1	t=2	t=3	t=4	t=5	t=6	t=7
Revenue	Deposit	100.0	-	-	-	-	-	-	-
	Loan	500.0	-	-	-	-	-	-	-
	Rentals	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	Sale	-	-	-	-	-	-	-	1,000.0
	Total	636.0	36.0	36.0	36.0	36.0	36.0	36.0	1,036.0
Expense	Purchase	1,000	-	-	-	-	-	-	-
	Loan Interest	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
	Registration tax	40.0	-	-	-	-	-	-	-
	Acquisition cost	15.0	-	-	-	-	-	-	-
	Depreciation cost	33.3	-	-	-	-	-	-	-
	Administrative cost	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Total	1,113.1	24.8	24.8	24.8	24.8	24.8	24.8	24.8
Net Profit		-477.1	11.2	11.2	11.2	11.2	11.2	11.2	1,011.2
Cash Flow		-477.1	10.9	10.6	10.3	10.1	9.8	9.6	839.2
NPV		423.38							

<Table 5> NPV calculation results for Shanghai

(Unit: One million won)

Classification		t=0	t=1	t=2	t=3	t=4	t=5	t=6	t=7
Revenue	Deposit	100.0	-	-	-	-	-	-	-
	Loan	500.0	-	-	-	-	-	-	-
	Rentals	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
	Sale	-	-	-	-	-	-	-	1,000.0
	Total	618.0	18.0	18.0	18.0	18.0	18.0	18.0	1,018.0
Expense	Purchase	1,000	-	-	-	-	-	-	-
	Loan Interest	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
	Registration tax	4.0	-	-	-	-	-	-	-
	Acquisition cost	10.0	-	-	-	-	-	-	-
	Depreciation cost	33.3	-	-	-	-	-	-	-
	Administrative cost	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
	Total	1,071.5	24.2	24.2	24.2	24.2	24.2	24.2	24.2
Net Profit		-453.5	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	993.8
Cash Flow		-453.5	-6.0	-5.9	-5.7	-5.6	-5.4	-5.3	824.7
NPV		337.3							

curred between January 2000 and December 2010. The estimated results for historical volatility show that the volatility in Seoul is 3.46% and 5.89% in Shanghai.

4.2.2. Estimation of option value

The value of the variables used to calculate the real option value of this project is shown in Table 6. To obtain the present value of the project's base assets (S), the present value of gross income discounted through the cash flows from traditional discount pricing can generally be used. Therefore, the underlying assets (S) are set at 1408.83 million and 1536.50 million, and the current prices of the present value of the total cost for the duration of the investments were set at 1113.12 million and 1071.53 million. The non-risk interest rate used assumed an investment on January 2, 2012; the interest rates for China’s and Korea's five-year national bonds, 3.47% and 5.32% respectively, were applied. The investment option expiration period was set at seven years. The calculation results from the binomial lattice option valuation model using the variables in Table 6 are shown in tables 7 and 8.

<Table 6> Variables for calculating option prices

Variable		Seoul	Shanghai
The net present value of the investment	S	1536.50	1,408.83
Exercise price	X	1113.12	1,071.53
Annual volatility	σ	3.46%	5.89%
Non-risk interest rate	R	3.47%	5.32%
Option expiration	T	7 year	7 year
Time interval	δ	1yera	1 year
Rise coefficient	U	1.034	1.061
Drop coefficient	D	0.966	0.943
Similar probability	P	1.001	0.949

<Table 7> Binomial lattice model calculation results for Seoul

Period	t=0	t=1	t=2	...	t=7
0	1,536.5	1,590.6	1,646.6	...	1,957.6
1		1,484.2	1,536.5	...	1,826.7
2			1,433.8	...	1,704.6
...				...	...
7					1,206.0

<Table 8> Binomial lattice model calculation results for Shanghai

Period	t=0	t=1	t=2	...	t=7
0	1,408.8	1,494.3	1,585.0	...	2,393.7
1		1,328.2	1,408.8	...	2,127.7
2			1,252.3	...	1,891.3
...				...	...
7					829.2

The expanded net present value (ENPV) and strategic value calculated based on the binomial lattice model with recursive backward iteration using Equation (3) are 663.4 million and 745.0 million respectively, as shown in table 9 and 10. These values represent the existing NPV and option values after considering project volatility. Seoul is the better investment alternative according to the traditional NPV method, but Shanghai is better according to the models that consider the options values.

<Table 9> Option value calculation results for Seoul

Period	t=0	t=1	t=2	...	t=7
0	663.4	686.7	710.8	...	844.5
1		580.3	600.7	...	713.6
2			498.0	...	591.4
...				...	...
7					92.9

<Table 10> Option value calculation results for Shanghai

Period	t=0	t=1	t=2	...	t=7
0	745.0	794.2	846.6	...	1322.2
1		628.1	670.5	...	1056.2
2			513.9	...	819.8
...				...	...
7					0

4.3. The value assessment of real estate using the PSC-Binomial Option Model

The variables and assumptions used to calculate the PSC-binomial option model are identical to those used in the binomial option model. However, the u, d, and p-values change at each time t because the PSC-binomial option model reflects the annual changes in population structure. The calculation results of the basic binomial lattice models using the variables in Table 11 and 12 are shown in table 13 and 14.

<Table 11> Detailed variables of the PSC-binomial option model for Seoul

Year	2013	2014	2015	2016	2017	2018	2019	2020
Population Growth Rate	0.994	0.999	0.999	0.999	0.999	0.997	0.996	0.995
u	-	1.022	1.022	1.023	1.024	1.016	1.011	1.008
d	-	0.979	0.978	0.978	0.976	0.984	0.989	0.992
p	-	1.318	1.299	1.281	1.231	1.577	2.147	2.831

<Table 12> Detailed variables of the PSC-binomial option model for Shanghai

Year	2013	2014	2015	2016	2017	2018	2019	2020
Population Growth Rate	1.078	1.036	1.035	1.033	1.031	1.029	1.027	1.024
u	-	1.176	1.152	1.128	1.102	1.076	1.049	1.022
d	-	0.851	0.868	0.887	0.907	0.929	0.953	0.978
p	-	0.628	0.657	0.697	0.756	0.854	1.054	1.725

<Table 13> The calculation result of the PSC-binomial option model for Seoul

Period	t=0	t=1	t=2	...	t=7
0	1,499.2	1,531.7	1,565.7	...	1,697.8
1		1,467.4	1,500.0	...	1,626.5
2			1,435.6	...	1,556.7
...				...	...
7					1,323.9

<Table 14> The calculation result of the PSC-binomial option model for Shanghai

Period	t=0	t=1	t=2	...	t=7
0	1,408.8	1,656.2	1,908.3	...	2,739.1
1		1,198.4	1,380.9	...	1,982.1
2			1,040.1	...	1,492.9
...				...	...
7					724.6

The ENPVs from the PSC-binomial option model calculation produce 688.0 million and 703.8 million, respectively, as shown in table 15 and 16, results that include the option values that consider change in population structure and the results of the original binomial options model.

<Table 15> The option value output in the PSC-binomial option model option for Seoul

Period	t=0	t=1	t=2	...	t=7
0	688.0	720.5	737.7	...	584.7
1		746.2	710.2	...	513.4
2			501.7	...	443.6
...				...	375.3
7					210.8

<Table 16> The option value output in the PSC-binomial option model option for Shanghai

Period	t=0	t=1	t=2	...	t=7
0	788.8	1010.0	1262.2	...	1667.6
1		531.5	688.1	...	910.6
2			316.3	...	421.4
...				...	102.3
7					0

Table 17 presents the results concerning investment values and decision-making for the methods under study. First, the DCF and binomial option valuation produce different decision-making results. Investing in Seoul seems to be a better choice according to the DCF method, but investing in Shanghai seems to be a better choice according to the binomial option method. As Seoul's real estate prices were declining, while Shanghai's were rising in September 2013, the binary option model produced the more accurate results. In addition, the PSC model, reflecting the newly proposed population structure, produced higher values than did the binomial options model, with 24.6 million in Seoul and 43.3 million in Shanghai, increases believed to be an accurate reflection of demographic changes. As Seoul's population is predicted to begin declining in 2016 and Shanghai's is predicted to increase until 2017, the changes in the cities' population structures conditioned the differences in their values.

<Table 17> Decision-making by methods

Method	Value		Selection
	Seoul	Shanghai	
DCF	423.4	337.3	Seoul
Binomial Option	663.4	745.5	Shanghai
PSC	688.0	788.8	Shanghai

5. Conclusion and Implications

This study, proposed a valuation method that considers changes in the population structure as a way of overcoming the limitations of existing studies on real estate value analysis. A binomial options model using real options techniques and a PSC-binomial model reflecting the changes in population structure defined by that binomial options model were employed. The correlation between demographic changes and real estate prices was analyzed using data extracted from the real estate markets in Shanghai and Seoul. The results show a positive correlation between the growth in real estate prices and changes in population structure. The correlation coefficient between the population structure change and real estate prices was estimated through OLS analysis, and the real estate values reflecting changes in the population structure were calculated with the coefficient using the binomial option model.

The results show that the DCF model is less useful for decision-making than is the binomial option model and that the value of real estate in the DCF model was lower than that in binomial option model because the former model inaccurately reflected the changes in real estate prices. The results of the PSC-binomial option model analysis that considered demographic changes showed that the value of Seoul real estate was 6.88 million won and that the value of Shanghai real estate was 7.888 million won, implying that the changes in the population structure were reflected in the values.

This study indicates that changes in population structure should be considered in research on real estate values. This study also provides a more accurate method of calculating the real option; existing studies have exploited the advantages of the real option only through the real option model and the DCF.

However, a further research is needed to develop an advanced method that considers all variables used in existing studies. Moreover, this study is limited specific domestic targets in its analysis of real estate values. More meaningful results can be expected from an expanded scope of research that evaluates data drawn from other countries. The PSC model, newly proposed model in this study reflecting the population structural changes, produced higher values than the binomial options model, with 24.6 million in Seoul and 43.3 million in Shanghai. Therefore, we can conclude that new proposed model accurately reflect the changes in the population structure.

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