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Estimating the Home-Purchase Cost of Seoul Citizens*

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Abstract

Seoul citizens are currently suffering from high housing price. Home prices have risen more rapidly than salaries so owning a housing unit (apartment, condominium, or single-family home) in Seoul is becoming more difficult than ever. Therefore, this research examines the behavior of average Seoul citizen in owning housing unit in Seoul, Korea, particularly in terms of the length of time required to afford a house unit. This research estimates that it will take about 18.75 years in maximum after getting a job (12.75 years after purchasing the housing unit) to own housing unit in Seoul that is currently valued at $300,000 where the growth rate of income is 2.97% and consumption price increases at a rate of 2.95% per annum. Finally in this research, the optimal growth rate of housing price is estimated ranged from 3.5 to 4.0% minimizing the loan payoff period.

Keywords: home-ownership, housing affordability, system dynamics, income (salary), expenditure, housing price, wealth effect.

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Ⅰ. INTRODUCTION

Home-ownership is very important to Korean people. It is regarded as a sign of success: thus, the Korean people think they have to own houses within their lifetime. Furthermore, owning real estates in Korea is the most common investment method utilized to increase the wealth of both people and companies. This is largely because the value of real estate increases more than any other assets. As housing prices rise, the investment on housing unit's construction will increase because of high return on investment(ROI) thus, the cost of home-ownership will increase(Linneman *et al.*, 1992).

This rising housing price lets homeowners realize a high return by selling their homes while people with no home-ownership, especially young people in Seoul give up or postpone owning housing units because the home-ownership is not affordable. This is due to the increasing gap between housing prices and their incomes. Due to skyrocketing housing prices in Seoul, households that are headed by individuals aged 30～44 are reported to be less able to afford home-ownership than older people.[1] It is also reported to take 22～24 years to own an apartment of 3-bedrooms and 2-bathrooms in Seoul.[2] So, young people have to rent, rather than to own.

The goal of this research is to examine when it is possible for young people in this current economy to own housing units after getting their jobs, especially for young people in Seoul. The behavior of average people in purchasing a housing unit shall be simulated. When the normal household in Seoul can own a housing unit with the assistance of a mortgage loan program and how long it takes for the household to be released from the pressure of a mortgage loan shall be investigated together. Furthermore, the optimal range of housing price growth rate to own housing units and complete the loan payment minimizing the loan payoff period will be examined and discussed.

1) http://news.donga.com/3/all/20091221/24946023/1

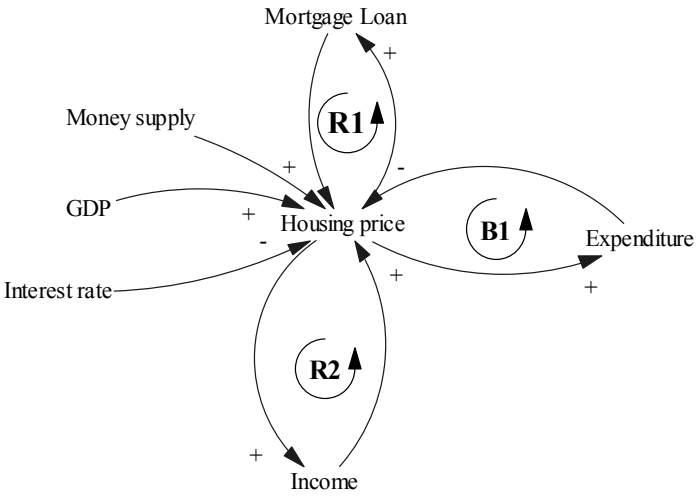
2) https://member.pressian.com/article/article.asp?article_num=30050609115005&Section=02

Ⅱ. LITERATURE REVIEW

Housing price seems to be related with the economic factors and housing policies (for economic factors, Sim, 2004, 2005, 2006; Kwon, 1996; Cho and Sung, 2004; Lee, 2008; for housing policies, Kwak and Lee, 2006). The related economic factors with the housing price are Gross Domestic Product(GDP), interest rate, money supply, consumer price, income, mortgage loan, and expenditure(Sim, 2005 and 2006). Housing price is revealed to have the significant bidirectional relationship with the mortgage loan, expenditure, interest rate, and income, however unidirectional relationship with GDP and Consumer Price Index(CPI)(Sim, 2005 and 2006). The remark from the previous research is that the housing price does not affect the consumer price(Kwon, 1996; Sim, 2005).

As far as concerned with the money supply, there is no significant relationship between money supply and consumption price after Korean currency crisis in 1997, while a proportional relationship between money supply and housing price before crisis(Sim, 2004). Sim(2005, 2006) has also tried to find the cyclical behaviors in the relationship between housing price and macroeconomic behaviors. Before Korean currency crisis, CPI significantly has the bidirectional causal relationship with the housing price however no significant causal relationship after the crisis. After economic crisis, loan and expenditure are affected by the housing price more than before economic crisis, which explains the wealth effect which obviously represents that the increase in housing price increases the permanent income, by increasing the asset value of house owner, and expenditure according to the permanent income theory(Lee, 2005; Lee, 2008) and the boom and bust cycle in the demand of housing market(Sim, 2006).

Based on Sim's research(2006) on the cyclical relationship between housing price and macroeconomic indicators, the causal loop diagram for macroeconomic factors is drawn as shown.

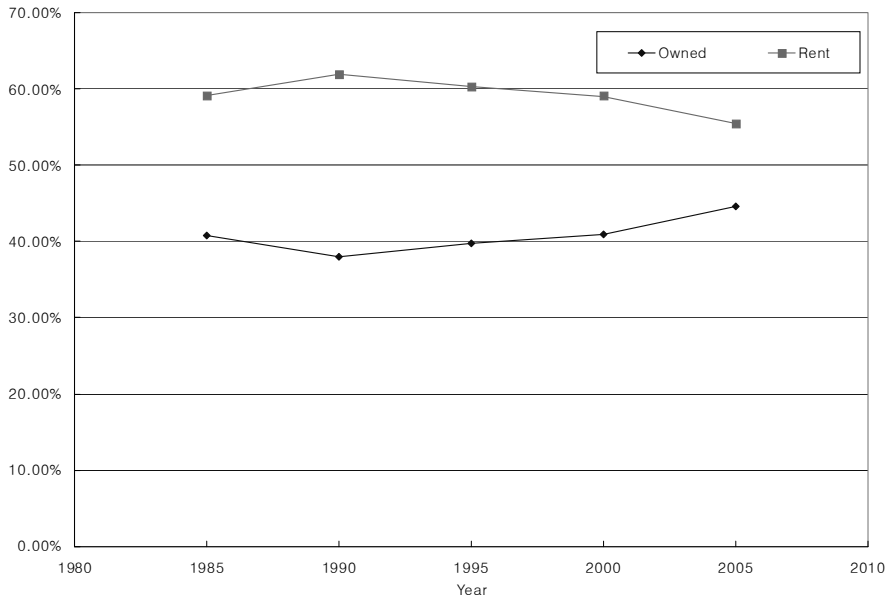


[Figure 1] Findings in the previous research

Within the system dynamics boundary, several articles exist regarding the housing market(price) and policy. Kang(2007) has tried to estimate the coefficients (determinants of housing cost) of a housing system dynamics model proposed by Kwon and Lee(2005) with the hierarchical linear model and finds that there is no significant school effect on the housing cost but the apartment size and the elapsed year of apartment significantly positively influence the housing cost. Kim(2007) applied the systems thinking and system dynamics modeling to housing markets as well as policies in Korea in order to understand the basic mechanism leading to the policy failure. He shows several causal loop diagrams regarding the real estate policy and a stock and flow diagram for the real estate system in Korea, especially for the apartment system, reflecting the recognition of policy makers and policy critics for the reality rather than mimicking the reality, to understand the effect of a policy on a market. Kim *et al.*(2010) analyze the urban management policies in the depopulation era with the system dynamics approach. When the population increases the goal of urban development plan can be accomplished as planned, however it is very difficult to reach when the population decreases because the revenue of a city decreases. They propose the balancing loop for the housing price: the development boosts the housing price, reducing the housing attractiveness which decreases the population inflow to a city.

Ⅲ. CURRENT STATUS OF SEOUL CITY

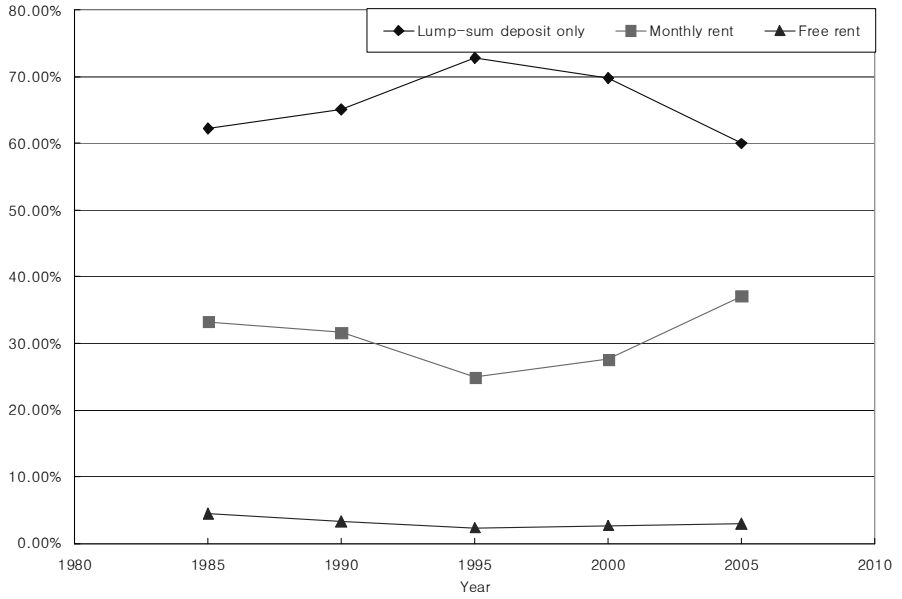
According to the statistics of Seoul city(2007), 44.59% of citizens own housing units while 55.14% rent as shown in [Figure 2] below. It can be inferred that high cost of owning a housing unit has become a big burden on the family and has resulted in more people renting housing units to save money. Yet, [Figure 2] tells us that renting has decreased as time progresses while owning a home has increased. It is thought to be because of a high expected ROI on housing units as housing price rises. From 2005 to 2008, housing prices rose faster than consumption prices so a high ROI was guaranteed(refer to Table 4).



[Figure 2] Trend of renting and owning housing unit

Specifically, rent is classified into lump-sum deposit, monthly rent, and free rent(Statistics of Seoul City, 2007). Lump-sum deposit is the authentic policy that is popular in Korea. This policy allows tenants not to pay monthly as they deposit a much larger amount of money to the landlords than the monthly rent fee. Landlords can earn money by depositing the money into an interest accruing bank account which would allow the landlord to acquire the monthly rent fee from the interest paid to the account(Hando, 1998). Portions of these three rent types

are compared in [Figure 3] below. It indicates that lump-sum deposit is much more popular than monthly rent in Seoul.



[Figure 3] Comparison of rent types

There are five types of housing units in Seoul: a house, an apartment, a row house, an apartment unit within a private house, and a dwelling unit in a non-residential building (Statistics of Seoul City, 2007). 〈Table 1〉 below shows the number of housing units per type. As the number of apartments and apartment units in a private house has increased, total number of housing units has also increased. However, during this increase in the number of

〈Table 1〉 Types of housing unit

Year	House	Apartment	Row house	Apartment units in a private house	Dwelling unit in a non-residential building	Total
2005	455,857	1,258,658	146,877	430,502	30,055	2,321,949
2006	450,818	1,307,113	145,278	436,479	30,055	2,369,743
2007	443,702	1,330,658	143,852	442,769	30,055	2,391,036

Source: Statistics of Seoul City, 2007

the two apartment types, the other types of housing units have decreased. Apartments have taken over 50% of the total housing units. This increase in the number of apartments is partially due to the preference of Seoul citizens to reside in an apartment over other types of housing units and the high expected ROI on an apartment caused by rising housing prices.

Next, household income in Seoul shall be investigated. In 2007 the average monthly income and expenditure for salary and wage earners' households in Seoul are 3,691.5 and 2,743.2 thousand Korean won. 〈Table 2〉 and 〈Table 3〉 below depict the specific monthly income and expenditure, respectively. As shown, monthly income has grown from 2,819 thousand Korean won in 2002 to 3,691.5 thousand Korean won in 2007. Monthly earnings are 3,223.7 thousand Korean won in 2007 and the earnings from the household head take the largest portion in total earnings. This means that the Korean family largely depends on the household head's earnings. Average growth rates of monthly income and earnings are calculated as 5.58% and 6.12%.

The annual growth rate of monthly expenditure, 4.58%, is lower than that of monthly income. On average expenditure has been 77.15% of income and 87.78% of earnings. The maximum ratio of expenditure to income is 78.0% and the minimum is 76.1%. For the ratio of expenditure to earnings, the maximum is 91.23% and the minimum 86.32%.

〈Table 2〉 Monthly income

(Unit: Korean won in thousands)

Year	Income	Earnings				Other
		Total	Household head	Spouse	Other household members	
2002	2,819.0	2,405.7	1,880.3	296.0	229.4	413.3
2003	3,082.1	2,742.0	2,132.5	333.3	276.2	340.1
2004	3,188.9	2,827.7	2,208.0	359.4	260.3	361.2
2005	3,223.4	2,849.6	2,203.6	363.4	282.6	373.8
2006	3,409.8	3,006.6	2,297.4	388.6	320.6	403.2
2007	3,691.5	3,223.7	2,449.3	428.5	345.9	467.9

Source: Statistics of Seoul City, 2007

〈Table 3〉 Monthly expenditure

(Unit: Korean won in thousands)

Year	2002	2003	2004	2005	2006	2007
Expenditures	2194.7	2366.8	2452.5	2515.5	2596.3	2743.2
Consumption expenditures	1904.6	2036.7	2074.8	2124.3	2163.8	2299.6
Food & beverages	508.3	535.2	554.0	559.7	552.0	570.1
Housing	69.8	69.9	68.2	74.8	90.4	92.3
Fuel, light & water charges	90.5	92.9	95.9	101.7	105.4	107.1
Furniture & utensils	78.0	78.0	73.5	86.9	90.8	101.2
Clothing & footwear	106.5	113.4	103.4	112.4	119.5	134.8
Medical care	81.9	95.5	97.8	106.0	106.2	108.5
Education	201.0	237.3	259.1	271.7	264.2	300.7
Culture & recreation	105.8	112.9	111.5	109.9	105.1	119.7
Transportation & communication	302.6	344.7	343.9	352.8	362.7	360.9
Other consumption expenditure	360.2	356.9	367.5	348.4	367.5	404.2
Non-consumption expenditures	290.1	330.1	377.7	391.2	432.5	443.6

Source: Statistics of Seoul City, 2007

〈Table 4〉 below shows the growth rate of salary, the consumer price index, and the unit price of apartment in Seoul from 2005 to 2008. This table tells us that the growth rate of salary oscillates over years but the consumer price index and the apartment price per 3.3㎡ are ever-increasing. Average growth rates of salary, the consumer price index, and the apartment price are calculated as 2.97%, 2.95%, and 13.27%. These growth rates shall be applied in this simulation.

〈Table 4〉 Trends of growth rate of salary, consumer price index, and apartment price

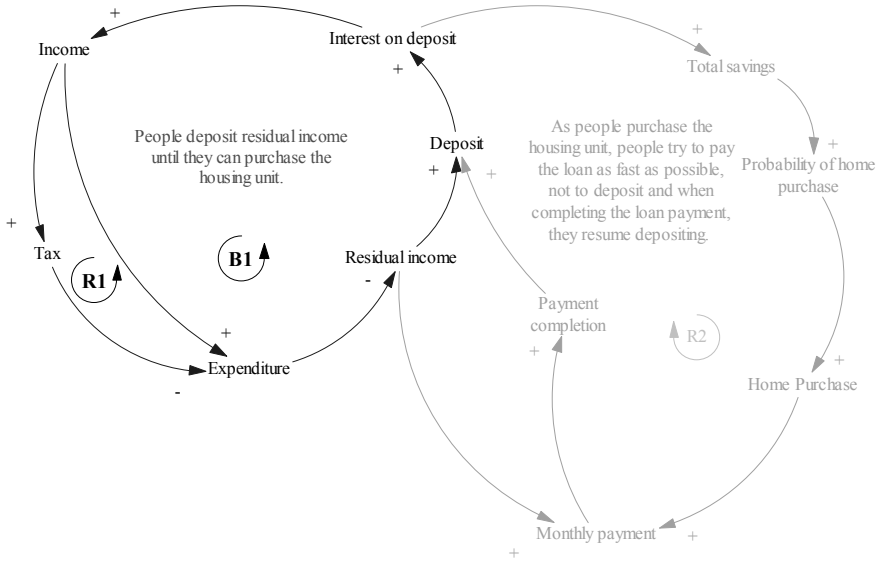
Year	Growth Rate of Salary (%)	Consumer Price Index	Apartment Price per 3.3 m2 (Korea won in thousands)
2005	3.29	100	12,405.0
2006	6.00	102.1	15,248.0
2007	4.20	104.8	17,408.0
2008	-1.60	109.1	17,885.0

Source: Statistics of Seoul City, 2007

Ⅳ. SIMULATION

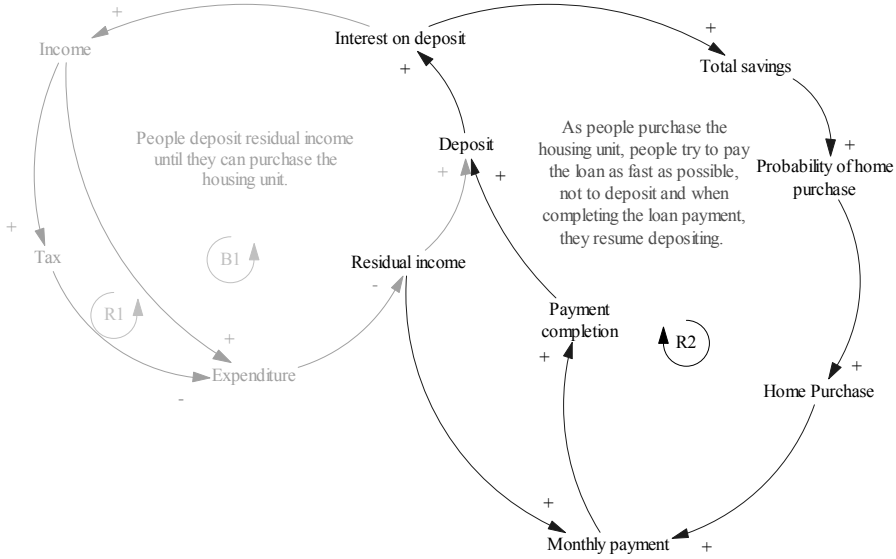
1. *Causal Loop Diagram*(*CLD*)

This research includes two CLDs. The first CLD is about the income increase due to depositing, the behavior before purchasing the housing unit. By subtracting taxes and household expenditure from the salary, the residual income is calculated. Before purchasing the housing units, people deposit it to their accounts and it creates the interest as a financial income so that the income increases eventually(refer to Figure 4).



[Figure 4] CLD for income and deposit

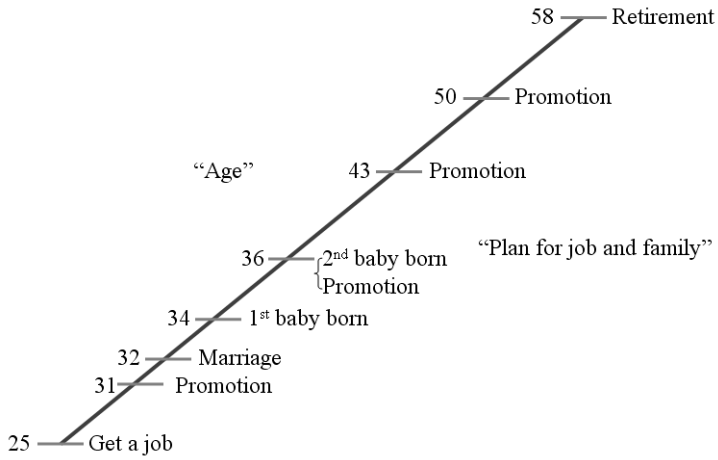
The second CLD is about home-purchase. As people continuously deposit, total savings increase, approaching the amount of money that is needed to purchase the house (i.e., the amount of (housing price * (1-loan coverage)). If total savings are equal to or greater than the needed money described above, people purchase the house then start paying the mortgage loan and try to complete the loan payment as soon as possible so pay the loan principal more if there is a residual income after paying the loan monthly constantly. After completion of loan payment, people resume depositing.



[Figure 5] CLD for deposit and home purchase

2. *Scenario*

In Korea, the earnings from the head of household are the largest portion of a family's earnings (refer to Table 2) so it is assumed that the household income comes only from the head of household. [Figure 6] depicts the scenario of a head of household for his career and family over life. He gets a job at age 25 and retires at 58. He gets married at 32 and has two children in his lifetime.



[Figure 6] Scenario for job and family

His salary increases as he is promoted. After retirement, he will get another job that provides him with a lower salary. His income is assumed to be as follows:

- age 25～30: $25,000/year,
- age 31～35: $32,000/year,
- age 36～42: $38,000/year,
- age 43～50: $46,000/year,
- age 51～58: $50,000/year,
- and age over 58: $25,000/year.[3)]

The income before retirement shall be increased annually by the growth rate of salary (2.97%). Initial income after retirement is set to be $25,000 and shall be increased by 2.97% annually after retirement age of 58.

Expenditure is assumed to increase as family members increase. The household spends $12,000 annually before marriage, that is, in the case of a single member family, and spends $20,000 per year in total after marriage but before having baby. As one baby is born, annual expenditure of household becomes $24,000 and after another baby is born, the household spends $28,000 annually. These expenditures shall be increased by the annual growth rate of consumer price (2.95%) in this simulation.

Income tax is assumed to be differentiated by the number of family members because the amount of deduction increases as family members increase. Income tax rates are depicted as follows:

- 1 family member: 10%,
- 2 family members: 8%,
- 3 family members: 6%,
- and 4 family members: 4%.

A mortgage loan program can cover up to 60% of the housing price so a household can own a housing unit when it has about 50% of the housing price (40% of the housing price plus other costs). The household deposits the amount of (income minus tax minus expenditure each year) until its deposit becomes more than 50% of the housing price. As its deposit

3) For calculation convenience, the currency of Korean won to dollar is assumed to be 1000 Korean won per dollar.

reaches the desired amount, the household buys a housing unit. After buying it, the household pays the mortgage loan, interest and a portion of principal. While paying the mortgage loan, it is assumed that the household shall not deposit money for a home purchase into its bank account.

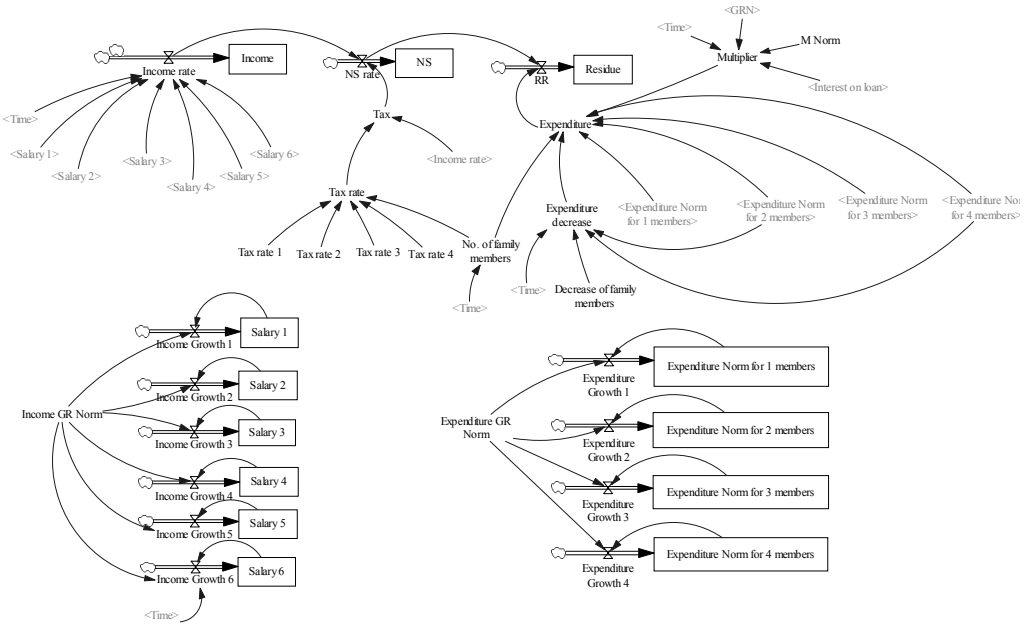
The interest rates on deposit and mortgage are set as the fixed rates of 4.5% and 6.1%, respectively. The latter is the average interest rate of mortgage loan programs in Korea.[4] The tax rate for buying housing unit is set to be 6% of the housing price and other cost is 5%. Finally, the housing price is initially set to be 300,000 dollars and shall be increased annually by the growth rate of housing price.[5]

3. *Stock and Flow Diagram*

This simulation shall be performed in Vensim™ program according to scenario explained above. The simulation model is formulated to be composed of 3 sectors: salary, mortgage, and deposit and loan payment. The salary sector deals with the dynamics of income, expenditure, tax, and residual income; the mortgage sector deals with the dynamics of housing price and mortgage loan; and the deposit and payment sector deals with the behavior of deposit and loan payment from residual income. Diagrams of the three sectors are shown in [Figures 7] through [Figure 9] below. The annual income and expenditure are shown in [Figure 7] below and the growth rates have been adapted to examine the dynamic behaviors of income and expenditure. In [Figure 9], the salary earner's household deposits the residual income into the bank account until the deposit reaches the amount of money necessary to own a housing unit, (total cost for housing-deposit) (refer to Figure 8). Then the household doesn't deposit until it pays off the mortgage loan, both the principal and the interest, completely. After completely paying the loan, the household restarts its monthly deposits.

4) http://www.khfc.co.kr/mortgage/mortgage_rate.jsp

5) It is assumed not to reflect the boom and burst cycle, as the purpose of this research is to know the average behavior of purchasing the housing unit.



[Figure 7] SFD of Salary

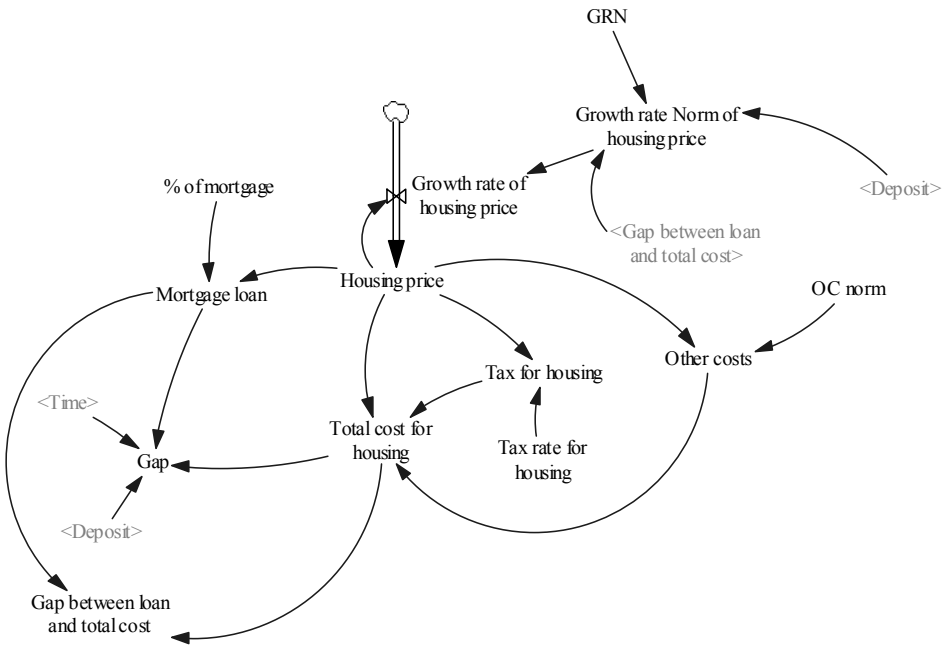
There are three main stocks standing for income, net income (expressed as "NS"), and residual income ("Residue") in the upper side of [Figure 7]. Six sets of salary are set to grow 2.97% ("Income GR Norm") annually in the lower left side and four sets of expenditure differentiated by the number of family members in the right side are also set to grow 2.95% ("Expenditure NGR Norm") annually. To express the wealth effect in this model, the multiplier shall be applied. The multiplier in this model is programmed as

"IF THEN ELSE (Interest on loan=0, IF THEN ELSE (Loan period=0, 1-M Norm, 1+M Norm), 1)"

where M Norm is set as 0.1. This equation means if interest on loan and loan period are equal to zero, that is to say, if there is no home purchase, the multiplier shall be 0.9, if interest on loan is equal to zero but loan period is not zero (if there is a home purchase), the multiplier shall be 1.1, and finally if interest on loan is not equal to zero, the multiplier will be one (1), and reflects the wealth effect explained above.

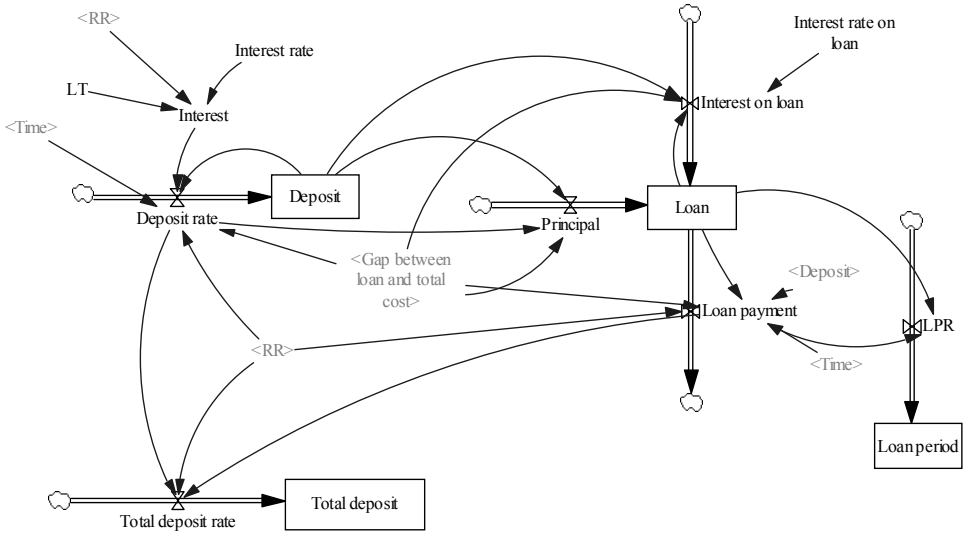
Next, consider the structure shown in [Figure 8]. "Housing price" is the core variable in the mortgage sector of the model because almost all variables inside this sector are related to and are calculated from it. Another important variable is "Gap between loan and total cost"

expressed as "(total cost for housing-mortgage loan)" in this simulation, which is the amount of money necessary to buy a housing unit. Growth rate Norm of housing price is set as
"IF THEN ELSE (Deposit="Gap between loan and total cost", 0, GRN)"
where GRN varies for calculation convenience.



[Figure 8] SFD of mortgage

In [Figure 9], as the household deposits more funds each year, interest on the deposit accrues. The deposit continues to grow from contributions and compounded interest. When the deposit exceeds the required gap between the price of the home and the maximum principal amount, the household buys the housing unit with the assistance of a mortgage loan program and then makes payments on the loan. This means the flow of annual residual income ("RR") is moved from the "Deposit rate" to the "Loan payment" if the deposit is greater than or equal to the necessary cash to own the housing unit. To simulate this dynamic movement, "Deposit rate" and "Loan payment" are set as
"IF THEN ELSE (Time=25, RR + Interest, if then else (Deposit=Gap between loan and total cost, 0, RR + Interest))" and



[Figure 9] SFD of deposit and loan payment

"IF THEN ELSE (Time=25, 0, if then else (Time>25, IF THEN ELSE (Loan=0, 0, if then else (Deposit=Gap between loan and total cost, IF THEN ELSE (RR=0, 0, RR), 0)), 0))", respectively.

Let's denote the growth rate of salary and the initial values of six salary sets as follows: growth rate of salary= GR_I=2.97%,

S_1^0=\$25,000/year, S_2^0=\$32,000/year, S_3^0=\$38,000/year, S_4^0=\$46,000/year, S_5^0=\$50,000/year, and S_6^0=\$25,000/year where S_i^0 is the initial value of ith salary level.

Salary is assumed to grow by the annual growth rate so the general term of salary except S_6^t is

$S_i^t = (1+GR_I)^t * S_i^0 \quad (t \geq 25)$ for $1 \leq i \leq 5$.

As S_6^t is assumed to increase when $t > 58$,

$S_6^t = (1+GR_I)^{t-58} * S_6^0 \ (t > 58)$.

This S_i^t is the annual income rate at t and the sum of income rate is total income so income rate and total income are expressed as

$IR = \frac{d(TI)}{dt} = 0$ when $t < 25$,

S_1^t for $25 \leq t \leq 30$,

S_2^t for $30 \leq t \leq 35$,

S_3^t for $35 \le t \le 42$,

S_4^t for $42 \le t \le 50$,

S_5^t for $50 \le t \le 58$,

and S_6^t for $58 \le t \le 80$

Total income= $TI = \int_0^t (IR)dt = \int_{25}^{30} S_1^t dt + \int_{30}^{35} S_2^t dt + \int_{35}^{42} S_3^t dt + \int_{42}^{50} S_4^t dt + \int_{50}^{58} S_5^t dt + \int_{58}^{80} S_6^t dt.$

Next, consider the household expenditures. For expenditures, the growth rate and the initial values of four expenditure norm sets are denoted as

Growth rate of consumption price= GR_E=2.95%,

EN_1^0=$12,000/year, EN_2^0=$10,000/year, EN_3^0=$8,000/year, and EN_4^0=$7,000/year where EN_k^0 is the initial value of expenditure norm when the number of family members is k.

The expenditure norm increases by the growth rate so the general term of expenditure norm is

$EN_k^t = (1+GR_E)^t * EN_k^0$ where $1 \le k \le 4$. Annual expenditure is calculated by

$AE = m * k * EN_k^t$ where the multiplier m is classified by purchasing the housing unit and paying the loan off as follows:

m=0.9 before purchasing the housing unit,

m=1 during loan payment,

and m=1.1 after completing loan payment.[6)]

As it is projected into the time frame, it is expressed as $AE = 0$ when $t < 25$,

$m * E_1^t$ for $25 \le t \le 32$,

$m * 2 * E_2^t$ for $32 < t < 34$,

$m * 3 * E_3^t$ for $34 < t < 36$,

$m * 4 * E_4^t$ for $36 < t < 58$,

and $m * 2 * E_2^t$ for $58 < t < 80$.

Annual residual income is calculated by $RR = IR - Tax - AE$. This goes to deposit rate as the household deposits. Total deposit is expressed as

$D_t = \int_0^t DR_t dt = \int_0^t RR_t * (1+I_d)dt$

6) Carroll *et al.* (2006) find the housing wealth effect is widely ranged from 4 to 10 % and 10% shall be applied to reflect the housing wealth effect in Korea as the volatility of housing price in Korea is much higher than that in U.S.

where D_t is the total deposit, DR_t is the annual deposit rate $(DR_t = RR_t * (1 + I_d))$, RR is the annual residual income, and I_d is the interest rate on deposit.

The housing price is calculated by

$$HR_t = (1 + GR_{HR})^t * HR_0$$

where GR_{HR} is the growth rate of housing price, HR_0 is the initial housing price, and HR_t is the housing price at time t.

The gap between total cost in buying a housing unit and amount of loan means minimum deposit amount needed to buy a housing unit expressed as

$$G_t = C_t - L_t = 1.11 * HR_t - 0.6 * HR_t = 0.51 * HR_t$$

where C_t is the total cost of buying a housing unit and L_t is the amount of loan.

The principal of loan is generally calculated by

$$P_t = P_{t-1} * (1 + I_l) - S_t \ (t \geq 1)$$

where P_t is the principal at time t, S_t is the payment of loan, and I_l is the interest rate on loan.

The principal, P_t, increases when $S_t < P_{t-1} * I_l$ and decreases when $S_t > P_{t-1} * I_l$. It can be expressed mathematically as follows:

$P_t > P_{t-1}$ when $S_t < P_{t-1} * I_l$

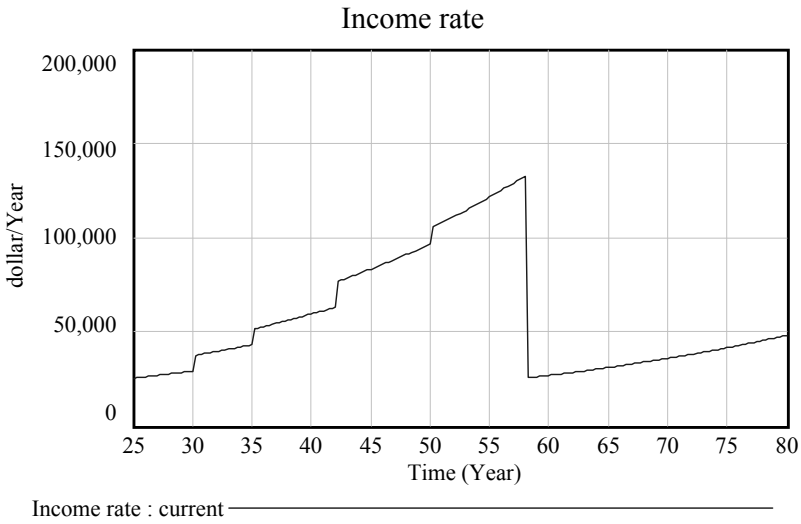
$P_t < P_{t-1}$ when $S_t > P_{t-1} * I_l$.

Initial value of the principal is $0.51 * HR_t$ in minimum because the household buys a housing unit when $D \geq 0.51 * HR_t$.

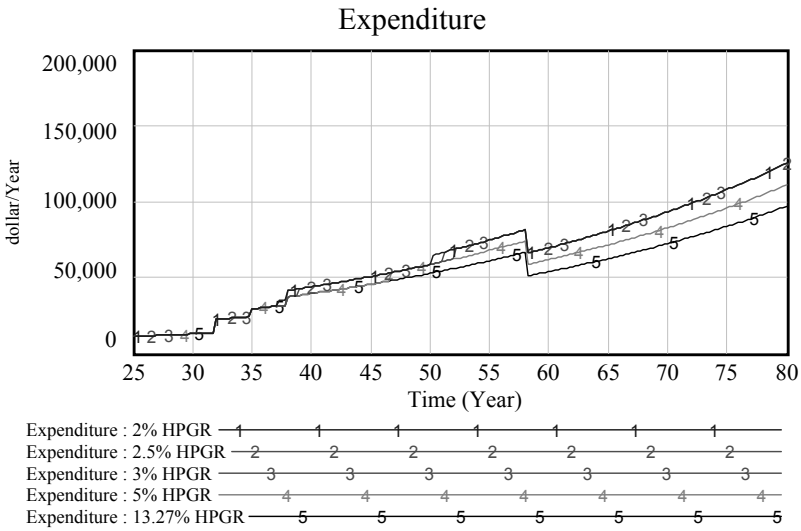
V. RESULTS

In this simulation, the assumed salary variable trajectory is shown in [Figure 10] below. After getting a job, income increases incrementally as the individual is promoted but declines heavily after retirement. So, the period leading from the age of getting a job to retirement age is the time to save money for life after retirement. [Figure 11] shows that expenditure increases by annual growth rate in spite of the reduced family members after retirement and is varied with the multiplier values. This various expenditure causes the various residual incomes shown in [Figure 12]. The residual income, that is, the available income to deposit or pay the loan, means that the available salary to deposit before buying a housing unit and pay the

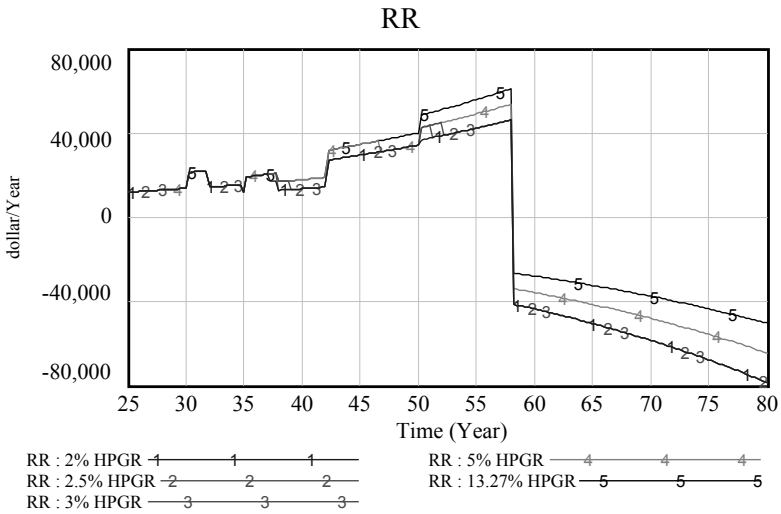
principal as well as the interest of loan after purchasing it. [Figure 12] below depicts the residual income after getting a job. As we can see, during the period of from age 25 to 58, there is a positive available salary but after 58, as salary is reduced after retirement, there is a shortage of available money. To solve this monetary shortage, the individual needs to have some additional jobs or sell the housing unit to replenish funds.



[Figure 10] Annual income



[Figure 11] Expenditure with flexible m



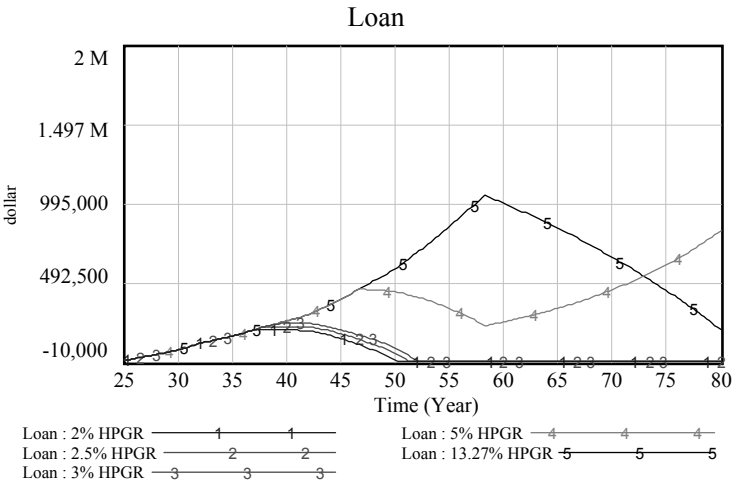
[Figure 12] Residual income with flexible m

[Figure 11] and [Figure 12] above show that 13.27% growth rate of housing price has the least expenditure and the greatest residual income because of unavailable home purchasing within lifetime. In this case, people cannot purchase their housing units as housing price grows faster than the income growth rate so the expenditure is revealed to be the least and the residual income the greatest because m=0.9.

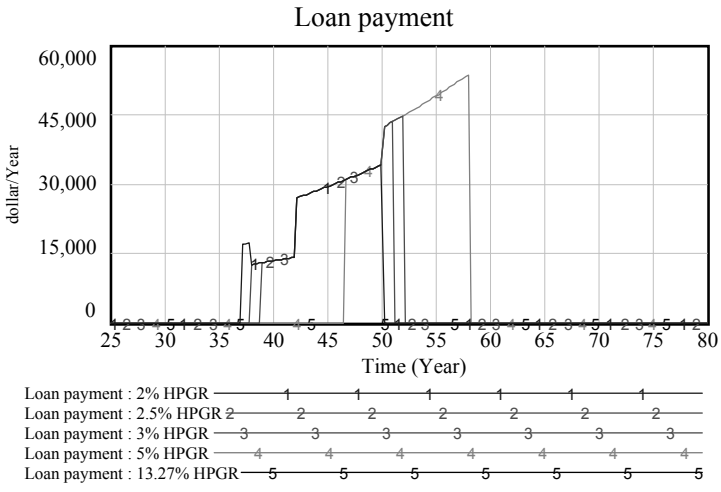
A simulation shall be performed for the following growth rates of housing price, 13.27%, 5%, 3%, 2.5%, and 2%. This will be performed to determine the optimal growth rate of housing price. This simulation allows us to know which growth rate of housing price related to those of salary and expenditure is optimal. [Figures 13] through [Figures 15] are the simulation results. These three figures show us that a 13.27% growth rate of housing price can lead the average Seoul citizen not to own a housing unit as explained above. In the case of 5% growth rate of housing price, it is estimated to be possible to own the housing unit at age 46.75 but the household can't afford to pay the loan completely because the household head is supposed to retire at age 58. Furthermore, the family income decline after retirement, which results in the household's selling the housing unit to replenish funds for life after retirement. In the cases of 2% and 2.5% growth rates of housing price, the head of household is estimated to have sufficient funds on deposit at age 37.25 and 38, respectively, and to pay the loan off perfectly at age 50 and 51, respectively. In the case of a 3% growth rate of housing price, it is estimated that the household head will have sufficient funds on deposit to

buy a housing unit at the age of 39 and pay off the loan perfectly at age 52. The lower growth rate of housing unit results in the earlier purchase of housing unit.

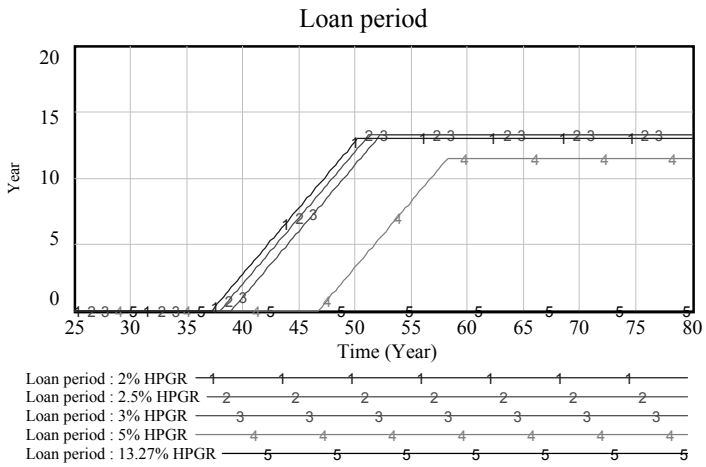
The loan payoff period, that is, the time it takes in paying off the loan principal is estimated to be 13 years in the case of 2% growth rate of housing price and 13.25 years in the cases of 2.5% and 3%(refer to Figure 15). The case of 2% growth rate of housing price is estimated to have the shortest loan payoff period (time between the start of loan and the retirement age 58) among cases of complete loan payoff, that is, except 5 and 13.27% of housing price growth rate.



[Figure 13] Total amount of loan



[Figure 14] Loan payment



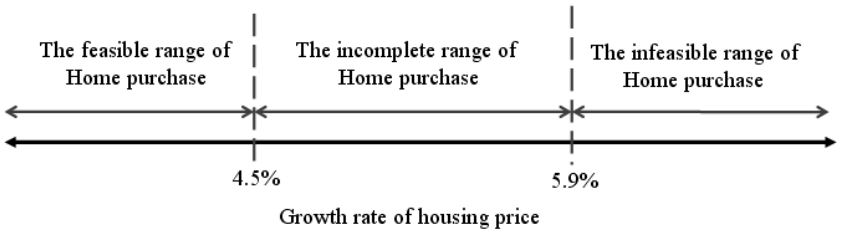
[Figure 15] Loan period

To obtain the feasible, incomplete-loan and infeasible ranges of growth rate of housing price, we shall perform the simulation varying the growth rate of housing price from 2% to 6% with the interval of 0.5%. The simulation result is summarized in 〈Table 5〉.

〈Table 5〉 The summary of simulation results

Growth rate of housing price	Age at which head of household can purchase house	Loan payoff period	Completion of loan payoff*	Years remaining to payoff mortgage
2.0%	37.25	13	1	20.75
2.5%	38	13.25	1	20
3.0%	39	13.25	1	19
3.5%	41	12.75	1	17
4.0%	42.75	12.75	1	15.25
4.4%	43.75	13.75	1	14.25
4.5%	44.5	13.75	0	13.5
5.0%	46.5	12.25	0	11.5
5.5%	51.25	7	0	6.75
5.8%	56.75	1.5	0	1.25
5.9%	-	-	-	-
6.0%	-	-	-	-
13.27%	-	-	-	-

* This simulation is performed under the assumption of 2.97% expenditure growth rate and 2.95% income growth rate. 1 means the complete loan payoff and 0 means the incomplete payoff.



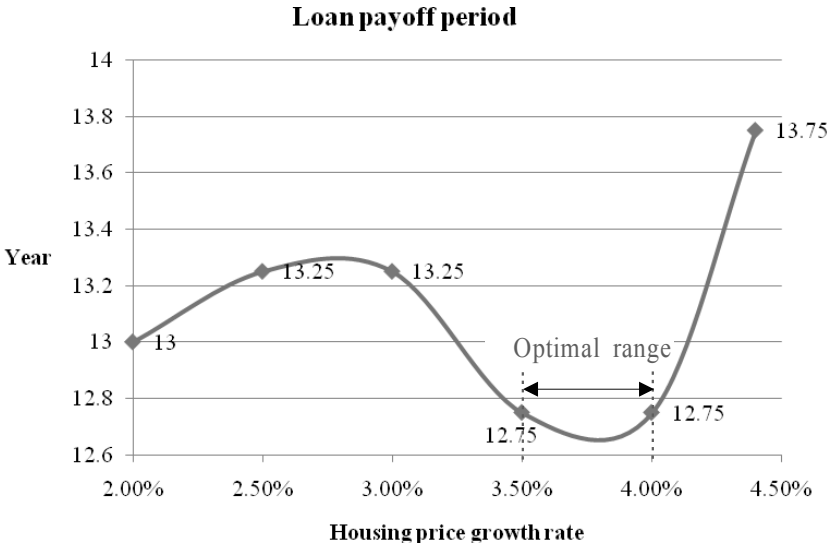
[Figure 16] Feasible, incomplete and infeasible range of growth rate of housing price

Based on the completion of loan payoff in 〈Table 5〉, three ranges of housing price growth rate can be defined as shown in [Figure 16]. First, let's see the infeasible range of housing price growth rate at which people cannot purchase the housing unit. For people to purchase the housing units during their life time, the growth rate of housing price should be below 5.9%. This means if the housing price growth rate is equal to or greater than 5.9%, people will give up their home purchase in their life when the growth rate of expenditure is 2.97% and the income growth rate is 2.95%. The second range to investigate is the incomplete loan range of housing price growth rate. When the housing price growth rate is equal to or greater than 4.5% and is below 5.9%, people purchase and own their housing unit but cannot complete the loan payment until 80. In this range, it will be better to sell the housing units than to own to replenish the funds. The timing to sell housing units will be the retirement age at which the fund shortage will occur. The third range is the feasible range of housing price growth rate. From 〈Table 5〉 above, the feasible range is revealed to be from 2.0% to 4.5%. In this range, people can purchase the housing units and complete the loan payment before retirement. People purchase at age 37.25 to 43.75. This means people own their housing units 12.25 to18.75 years after getting jobs and 5.25 to 11.75 years after marriage.

The loan payoff period is ranged from 12.75 to 13.75 years and the minimum loan payoff period is 12.75 years in the cases of 3.5 % and 4% of growth rate of housing price. This means though, in the 3.5～4% range of housing price growth rate, people can purchase the housing units later than lower growth rate cases, people will pay the loan off faster than other cases. The age of household head at which the loan payoff is completed is ranged from 50.25 to 57.5. This means the household head will release the burden of loan payoff at fifties. So people will own their housing units with no debt about 20 years after marriage.

Within the feasible range, the optimal range can be found, minimizing the loan payoff

period: The shorter period, the better to Seoul citizens. [Figure 17] illustrates the loan payoff period versus housing price growth rate. The minimum period is 12.75 years at 3.5% and 4% housing price growth rate. Therefore, the range from 3.5% to 4% is conclusively the optimal range of housing price growth rate to minimize the loan payoff period in this research.



[Figure 17] Optimal range of housing price growth rate to minimize the loan payoff period

Ⅵ. CONCLUSIONS

Simulation results show that if the growth rate of housing price is equal to or greater than 5.9% people shall give up their home purchase, if it is within the range of from 4.5% to 5.9% people will not complete the loan payment though they purchase the housing units, and if it is within the range of below 4.5% people will purchase their housing units and complete the loan payment before retirement under the assumption of 2.97% salary growth rate and 2.95% expenditure increase rate. Regarding the loan period, the minimum is estimated to be 12.75 years in the cases of 3.5% and 4% of growth rate of housing price, and the maximum 13.75 years in the case of 4.4% housing price growth rate.

Housing price is an important determinant of the home-ownership affordability: Rising

prices impede prospective home-buyers' accumulation of home down payments as a percentage of home price and also raise the required monthly mortgage payment for a mortgage loan of a given type; as a result, buyers must have higher incomes to meet qualifying criteria thus, housing price is very critical in the housing market(Linneman and Megbolugbe, 1992). Therefore, Korean government should try to stabilize the housing price to alleviate the increasing burden of owning housing unit, to prevent the derivative effect of rising housing prices, and to stabilize the housing market.

This research investigated the optimal growth rate of housing price under fixed growth rates of salary and expenditure and fixed interest rates on deposit and loan. In other words, these rates are set as exogenous. Further studies will investigate the optimal housing price appreciation rate under varying and inter-relating the growth rates of salary and expenditure and interest rates. This means these rates shall be endogenous in the future research to provide more dynamics to the model. These relationships can limit the variables — salary, expenditure, interest and housing price — so it may more specifically reflect reality. To inter-relate these rates, economic growth rate can be adapted basically. The source of these rates shall be the economic growth rate and it will let all variables except economic growth rate endogenous and reflect the real dynamism.

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【APPENDIX A. Equations】

(1) "% of mortgage" = 0.6
Units: Dmnl

(2) Decrease of family members = 2
Units: capita

(3) Deposit = INTEG (Deposit rate, 0)
Units: dollar

(4) Deposit rate = if then else (Time=25, RR + Interest, if then else (Deposit>=Gap between loan and total cost, 0, RR + Interest))
Units: dollar/Year

(5) Expenditure = if then else ("No. of family members"=0, 0, if then else ("No. of family members"=1, Expenditure Norm for 1 members * "No. of family members" * Multiplier, if then else ("No. of family members"=2, Expenditure Norm for 2 members * "No. of family members" * Multiplier, if then else ("No. of family members"=3, Expenditure Norm for 3 members * "No. of family members" * Multiplier, Expenditure Norm for 4 members * "No. of family members" * Multiplier)))) - Expenditure decrease
Units: dollar/Year

(6) Expenditure decrease = if then else (Time>58, (Expenditure Norm for 2 members - Expenditure Norm for 4 members) * Decrease of family members, 0)
Units: dollar/Year

(7) Expenditure GR Norm = 0.0295
Units: 1/Year

(8) Expenditure Growth 1 = Expenditure Norm for 1 members * Expenditure GR Norm
Units: dollar/(Year*Year)/capita

(9) Expenditure Growth 2 = Expenditure Norm for 2 members * Expenditure GR Norm
Units: dollar/(Year*Year*capita)

(10) Expenditure Growth 3 = Expenditure Norm for 3 members * Expenditure GR Norm
Units: dollar/(Year*Year*capita)

(11) Expenditure Growth 4 = Expenditure Norm for 4 members * Expenditure GR Norm
Units: dollar/(Year*Year*capita)

(12) Expenditure Norm for 1 members = INTEG (Expenditure Growth 1, 12000)
Units: dollar/Year/capita

(13) Expenditure Norm for 2 members = INTEG (Expenditure Growth 2, 10000)
Units: dollar/(Year*capita)

(14) Expenditure Norm for 3 members = INTEG (Expenditure Growth 3, 8000)
Units: dollar/(Year*capita)

(15) Expenditure Norm for 4 members = INTEG (Expenditure Growth 4, 7000)
Units: dollar/(Year*capita)

(16) FINAL TIME = 80
Units: Year
The final time for the simulation.

(17) Gap = if then else (Time>25, Total cost for housing - Deposit - Mortgage loan, 0)
Units: dollar

(18) Gap between loan and total cost = Total cost for housing - Mortgage loan
Units: dollar

(19) GRN = 0.044
Units: 1/Year

(20) Growth rate Norm of housing price = if then else (Deposit>=Gap between loan and total cost, 0, GRN)
Units: 1/Year

(21) Growth rate of housing price = Housing price*Growth rate Norm of housing price
Units: dollar/Year

(22) Housing price = INTEG (Growth rate of housing price, 300000)
Units: dollar

(23) Income = INTEG (Income rate, 0)
Units: dollar

(24) Income GR Norm = 0.0297
Units: 1/Year

(25) Income Growth 1 = Salary 1 * Income GR Norm
Units: dollar/(Year * Year)

(26) Income Growth 2 = Salary 2 * Income GR Norm
Units: dollar/(Year * Year)

(27) Income Growth 3 = Salary 3 * Income GR Norm
Units: dollar/(Year * Year)

(28) Income Growth 4 = Salary 4 * Income GR Norm
Units: dollar/(Year * Year)

(29) Income Growth 5 = Income GR Norm * Salary 5
Units: dollar/(Year * Year)

(30) Income Growth 6 = if then else (Time>=58, Income GR Norm * Salary 6, 0)
Units: dollar/(Year * Year)

(31) Income rate = if then else (Time<25, 0, if then else (Time<=30, Salary 1, if then else (Time<=35, Salary 2, if then else (Time<=42, Salary 3, if then else (Time<=50, Salary 4, if then else (Time<=58, Salary 5, Salary 6))))))
Units: dollar/Year

(32) INITIAL TIME = 25
Units: Year
The initial time for the simulation.

(33) Interest = RR * Interest rate*LT
Units: dollar/Year

(34) Interest on loan = if then else (Loan>0, if then else (Deposit>=Gap between loan and total cost, Loan * Interest rate on loan, 0), 0)
Units: dollar/Year

(35) Interest rate = 0.045
Units: 1/Year

(36) Interest rate on loan = 0.061
Units: 1/Year

(37) Loan = INTEG (Interest on loan + Principal－Loan payment, 0)
Units: dollar

(38) Loan payment = if then else (Time=25, 0, if then else (Time>25, if then else (Loan<=0, 0, if then else (Deposit>=Gap between loan and total cost, if then else (RR<=0, 0, RR), 0)), 0))
Units: dollar/Year

(39) Loan period = INTEG (LPR, 0)
Units: Year

(40) LPR = if then else (Loan payment>0, 1, 0)
Units: Dmnl

(41) LT = 1
Units: Year

(42) M Norm = 0.1
Units: Dmnl

(43) Mortgage loan = "% of mortgage" * Housing price
Units: dollar

(44) Multiplier = if then else (Interest on loan=0, if then else (Loan period=0, 1 - M Norm, 1 + M Norm), 1)
Units: Dmnl

(45) "No. of family members" = if then else (Time>=38, 4, if then else (Time>=35, 3, if then else (Time>=32, 2, if then else (Time>=25, 1, 0))))
Units: capita

(46) NS = INTEG (NS rate, 0)
Units: dollar

(47) NS rate = Income rate - Tax
Units: dollar/Year

(48) OC norm = 0.05
Units: Dmnl

(49) Other costs = OC norm * Housing price
Units: dollar

(50) Principal = if then else (Deposit<Gap between loan and total cost, Deposit rate, 0)
Units: dollar/Year

(51) Residue = INTEG (RR, 0)
Units: dollar

(52) RR = NS rate - Expenditure
Units: dollar/Year

(53) Salary 1 = INTEG (Income Growth 1, 25000)
Units: dollar/Year

(54) Salary 2 = INTEG (Income Growth 2, 32000)
Units: dollar/Year

(55) Salary 3 = INTEG (Income Growth 3, 38000)

Units: dollar/Year

(56) Salary 4 = INTEG (Income Growth 4, 46000)

Units: dollar/Year

(57) Salary 5 = INTEG (Income Growth 5, 50000)

Units: dollar/Year

(58) Salary 6 = INTEG (Income Growth 6, 25000)

Units: dollar/Year

(59) SAVEPER = TIME STEP

Units: Year [0,?]

The frequency with which output is stored.

(60) Tax = Tax rate * Income rate

Units: dollar/Year

(61) Tax for housing = Tax rate for housing * Housing price

Units: dollar

(62) Tax rate = if then else ("No. of family members"=1, Tax rate 1, if then else ("No. of family members"=2, Tax rate 2, if then else ("No. of family members"=3, Tax rate 3, Tax rate 4)))

Units: Dmnl

(63) Tax rate 1 = 0.1

Units: Dmnl

(64) Tax rate 2 = 0.08

Units: Dmnl

(65) Tax rate 3 = 0.06

Units: Dmnl

(66) Tax rate 4 = 0.04

Units: Dmnl

(67) Tax rate for housing = 0.06

Units: Dmnl

(68) TIME STEP = 0.25

Units: Year [0,?]

The time step for the simulation.

(69) Total cost for housing = Housing price + Other costs + Tax for housing
Units: dollar

(70) Total deposit = INTEG (Total deposit rate, 0)
Units: dollar

(71) Total deposit rate = Deposit rate + if then else (Loan payment<=0, RR, 0)
Units: dollar/Year