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Accounting for Changes in House Prices and Rent in Korea, 2001–2016*

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We quantitatively evaluate the relative contribution of macroeconomic fundamentals and housing-related policies to the changes in real house prices, rent, and household welfare in Korea. We show that the observed changes in real house prices and rent in 2001–2016 are mainly attributed to a decrease in the real interest rate, an increase in real income, and an increase in the aggregate housing supply. However, housing-related policies turn out to have little impact on the price changes, contrary to the common belief that such policies significantly affected the housing market over this period. We also find that the welfare implications of fundamentals and housing-related policies vary by household income.

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I. Introduction

Houses are not only necessities, providing shelter, but also real assets through which households accumulate wealth for precautionary motives. According to the Survey of Household Finances and Living Conditions (SFLC) in 2016, a substantial portion (around 70 percent) of the total household assets in Korea consist of real estate. This implies that any changes in house prices and rent greatly affect the balance sheets of households and have significant effects on the real

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economy in aggregate. For this reason, government interventions in the housing market are active in Korea.

Figure 1 documents the evolution of the Korean housing market from 2001 to 2016. The real house prices increase by 27.6% and the real rent decreases by 2.1%. Over the same period, we also observe changes in economic fundamentals. The real saving rate falls from 4.1% to 0.9%, and the real mortgage rate falls from 5.6% to 2.2%. The real household nonfinancial income rises by 21%, and the housing supply expands by 14%. Additionally, the government introduced mortgage debt limits, such as the loan-to-value (LTV) ratio and the debt-to-income (DTI) ratio,[1] during the studied period. The property holding tax and the acquisition tax[2] have also changed over time.

The purpose of this paper is to quantitatively evaluate the effects of macroeconomic fundamentals and housing-related policies on real house prices, rent, and household welfare in Korea. To this end, we have adopted a model of heterogeneous households with incomplete markets where households can buy or rent houses of various size for residence as well as to be a landlord by leasing out their properties in the rental market. House prices and rent are endogenously determined by the optimal choice of households within the model. Thus, our model serves as a useful vehicle to evaluate the changes in real house prices, rent, and welfare in response to various exogenous factors, and we quantitatively assess the relative contribution of these factors to the observed price changes in Korea.

We considered the exogenous factors that are believed to influence real house prices and rent: real interest rate, real household income, aggregate house supply, borrowing constraints such as LTV and DTI conditions, property tax, and acquisition tax. Then, we fed the changes of each factor observed over the period (2001–2016) in Korea into the calibrated model to evaluate the contribution of each factor to the changes in real house prices, rent, and household welfare. That is, we performed a series of counterfactual experiments to quantify the contributions of these factors to house prices and rent from a long-term perspective.

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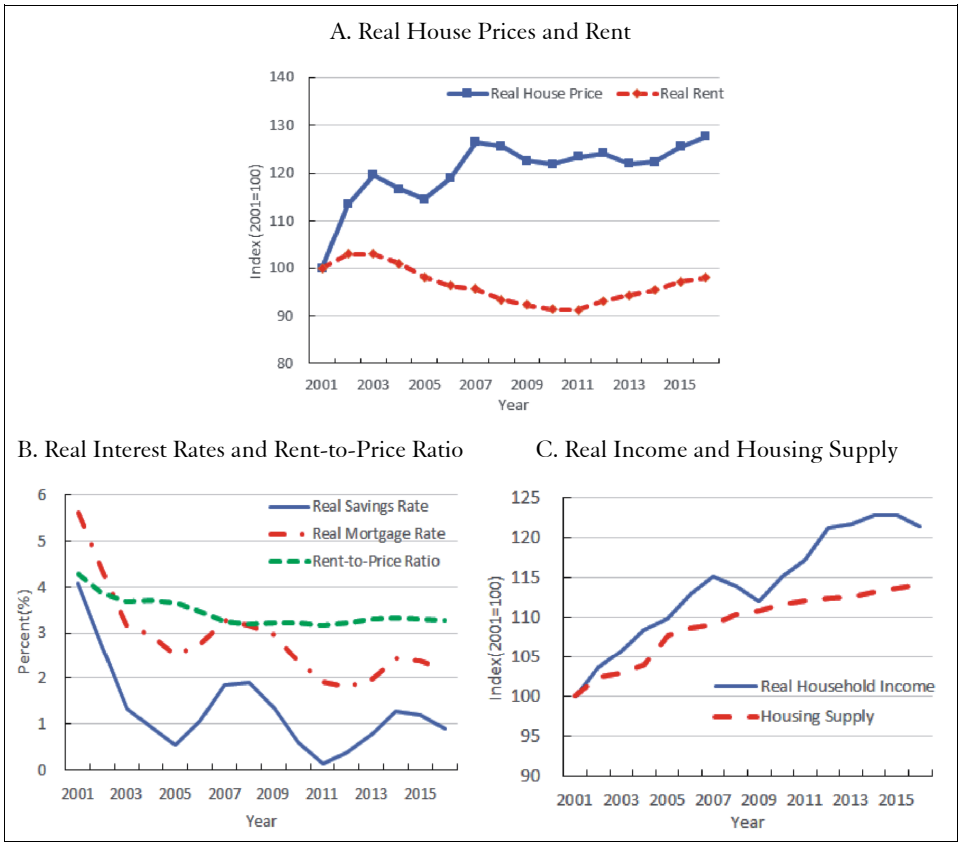
[1] An LTV regulation with a limit of 60% was first introduced in September 2002 and a DTI regulation of 40% in August 2005. As the house price continued increasing even under these regulations, the government gradually extended these regulations to loans from nonbanking financial institutions and capital areas, and the DTI limit was tightened to 60% for certain speculative areas until 2007. After the financial crisis in 2008, the relevant authority started to loosen the regulations, and in 2014, the LTV and DTI limits were set to 70% and 60%, respectively. For a more detailed description of the policy changes, see Park (2017).

[2] See NABO (2018) for a detailed description of the various changes in the real estate taxes over the studied period.

[Figure 1] Evolution of the Korean Housing Market from 2001 to 2016



The findings are as follows. First, the model captured the changes in house prices and rent observed in the data reasonably well. With the observed changes in the exogenous factors over the period from 2001 to 2016, the model predicted that the real house prices would increase 34.8% and the real rent decrease 2.5%, while the data show a 27.6% increase in real house prices and a 2.1% decrease in real rent over the same period. Second, our counterfactual experiments show that the changes in real house prices and rent observed are mostly attributed to a decrease in the real interest rate, an increase in real income, and an increase of the aggregate house supply over the studied period. On the other hand, changes in policies, such as regulations on the LTV and DTI limits, and real estate taxes observed over the same period turn out to have little impact on house prices and rent, contrary to the common belief that such policies have significant effects on housing prices. Third, the average welfare improved over the years in the model, but each factor had a different impact on household welfare. Whereas the decrease in the real interest rate resulted in a welfare loss for all earnings groups, their welfare improved through the increase in real income and aggregate house supply. The tightened LTV limit

worked in favor of those who have high labor earnings, and the tightened DTI limit also improved welfare. Furthermore, the rich benefited from the decrease in the property tax rate, but the change in the acquisition tax rate was beneficial to those whose earnings are low.

Several recent studies, including Sommer et al. (2013), Sommer and Sullivan (2018), Kiyotaki et al. (2011), and Favilukis et al. (2017), have developed a general equilibrium model of housing to explain how house prices and rent are determined in equilibrium. Sommer et al. (2013) used a dynamic equilibrium model of housing to study the effects of fundamentals on house prices and rent. Sommer and Sullivan (2018) studied the implications of the U.S. tax policy for house prices, rent, and homeownership. Kiyotaki et al. (2011) used a lifecycle model to analyze the effects of exogenous changes in productivity, interest rate, and financing constraints on house prices. Favilukis et al. (2017) studied a quantitative general equilibrium model of housing with aggregate business cycle risk and realistic wealth distribution.

Our model is based on that of Sommer et al. (2013) but differs from their work in several dimensions to reflect the Korean economy. We abstracted from the stochastic aging and utilized the AR (1) process for labor earnings. This structure enables us to account for the share of landlords increasing as income rises in Korea. Also, in addition to the LTV ratio limit, we considered the regulation of the DTI ratio to assess the effects of changes in financial regulations on mortgages. Furthermore, for both 2001 and 2016, we carefully parameterized the Korean tax system in great detail: property tax, acquisition tax, comprehensive income tax, and social insurance contributions.

Our work is also related to two strands of Korean literature on house prices and rent in Korea. In the first group, Lee and Kim (2016), Kim (2012), and Son (2010) studied the effects of monetary policy and interest rates on house prices and rent using VAR analyses. In contrast to these studies, we employ a structural equilibrium model where the optimal behavior of heterogeneous households determines the house prices and rent within the model. This framework, unlike the works above, enables us to perform counterfactual experiments to examine (i) how a variety of economic and policy factors affect house prices and rent in equilibrium and (ii) how the distribution of households evolves given the price changes. In the second group of works that use a structural model similar to ours, Moon (2015) used the overlapping generation model to study the effects of housing assets on labor supply decisions over the lifecycle, and Song and Kim (2013) examined the effects of observed changes in housing finance on household consumption and savings. Unlike these works, (i) we specifically focused on the housing market and analyzed an equilibrium where both house prices and rent were endogenously determined respectively, and (ii) we modeled a rich set of macroeconomic and policy factors to study their impact on house prices, rent, and household welfare. To our knowledge, this is the first attempt to use a computable equilibrium model of heterogeneous

households with the housing market to decompose the observed variation in house prices and rent by economic fundamentals and policy factors in Korea. In these regards, our work contributes to the existing literature.

This paper is organized as follows. Section II describes the model. Section III presents the calibration and a validation study of the model. Section IV describes the counterfactual experiments to account for the changes in house prices, rent, and welfare in Korea. Section V concludes the paper.

II. Model

We adopted the model economy developed by Sommer et al. (2013) and modified it to reflect the Korean income process and housing market arrangements. In particular, we carefully modeled the Korean tax code and financing regulations, which are required to evaluate the effects of these policies on house prices and rent.

In an Aiyagari-Bewley-Huggett type economy, households choose the consumption of shelter services as well as nondurable goods by either owning or renting houses. The borrowing is regulated by the LTV and DTI limits, and households pay taxes on their labor earnings, on their interest income from financial assets, and for owning houses (property tax). Households trade houses in the market, and the house price and rent are endogenously determined within the model. The detailed model specification follows.

2.1. Demographics, Preferences, and Residence

The model economy is populated by ex-ante identical households of a unit measure. Each household has a probability of death, $1-\phi$, and the deceased households are replaced by an equal number of newborn households.[3]

Households derive their utility from the consumption of nondurable goods and shelter services each period and maximize their expected discounted lifetime utility in the following formula:

$$E_0\left[\sum_{t=0}^{\infty}(\beta\phi)^t u(c_t, h_t', s_t)\right]$$

where β is the discount factor, c_t is consumption of nondurable goods, h_t' is the holdings of the housing stock, and s_t is the shelter services at time t.

[3] We assume that all the assets held by deceased households are confiscated by the government and that their houses are all resold in the market immediately. Newborn households hold no financial assets and rent a house for shelter.

Houses are traded at the market price p per unit size. If a household chooses to possess a certain amount of the housing stock, that further determines whether a part of its housing stock is leased out. Thus, there are three types of households in terms of residence: (i) renters $(h_t' = 0, s_t > 0)$, who do not own houses and who pay for shelter services at the rental rate of ρ per unit size; (ii) owner-occupiers, who own one property $(h_t' = s_t > 0)$ and use all the housing stock they own for their own shelter services; and (iii) landlords, who own multiple properties $(h_t' > s_t > 0)$, lease out some portion of their housing stock $(h_t' - s_t > 0)$, and receive rental income of $\rho(h_t' - s_t)$.

We assume that the period utility function takes the Cobb-Douglas form:

$$u(c_t, h_t', s_t) = (1 - \chi I_{h'>s}) \frac{(c^{\alpha} s^{1-\alpha})^{1-\sigma} - 1}{1-\sigma},$$

where α is the relative importance of nondurable goods consumption, σ is the risk aversion for the composite consumption of nondurable goods and shelter services, and $I_{h'>s}$ is the indicator function that takes 1 for landlords, and 0 otherwise. The utility cost χ is incurred for landlords, as in Sommer et al. (2013).

2.2. Income

There are three types of household income in our model: i) rental income for landlords, written as $\rho(h' - s)$, as described above; ii) interest income from financial assets, written as ra where a is the financial asset position carried over from the last period and r is the deposit interest rate given exogenously; and iii) labor earnings, wz, written as the product of the efficiency unit wage rate w and idiosyncratic productivity z. The productivity is assumed to follow an independent AR(1) stochastic process:

$$\log z' = \rho_z \log z + \varepsilon', \quad \varepsilon' \sim N(0, \sigma_z^2),$$

where ρ_z governs the persistence and σ_z^2 is the variance of productivity innovation ε' drawn from a normal distribution.

2.3. Borrowing Limits

Households can partially insure against earnings risk by borrowing against the housing stock they own as well as through financial savings. To reflect the heavy regulation of household loans in Korea, we adopted the LTV and DTI limits as follows:

$$m' \le \mu p h',$$
$$\frac{(1+r_m)^n r_m}{(1+r_m)^n - 1} m' \le \nu\{wz + ra + I_{h'>s}\rho(h'-s)\}.$$

The first inequality requires that households can borrow m' up to the μth fraction of the house value they own ph' (LTV condition). Or equivalently, purchasing a house with the value of ph' requires a minimum down payment of $(1-\mu)ph'$. We assume that the borrowings or mortgage loans are long-term, fixed-rate contracts with equal installments every period. Thus, the second inequality shows that each installment for the borrowing of m' with maturity n cannot exceed the νth fraction of the total income per period (DTI limit). Note that the interest rate for the mortgage contract is exogenously given as r_m, different from that for deposits, r.

2.4. Transaction Costs and Taxes

Transaction costs and taxes are incurred in housing trades: We write the brokerage commission plus property acquisition tax as $T_b(p,h',s)$ for purchasing houses and the brokerage commission for selling houses as $T_s(p,h')$. Additionally, households pay property possession tax, $T_h(p,h',s)$, for every period that they hold the housing stock. The housing stock depreciates at a rate of δ.

We also model income tax and social insurance premiums. We assume that financial income below $\underline{\tau}$ is separately taxed, while amounts that exceed $\underline{\tau}$ are consolidated into labor earnings and subject to comprehensive taxation. We write separate taxes for financial income $T_{inc,f}$ as $T_{inc,f} = \tau_f \min\{ra, \underline{\tau}\}$, where τ_f is a separate tax rate for financial income.

The tax base for rental income tax is the τ_{rc}th fraction of the total rental income minus the deduction of τ_{rd}. Any rental income less than $\underline{\tau}$ is separately taxed, while any amount that exceeds it is subject to comprehensive taxation along with labor earnings. The rental income tax $T_{inc,r}$ is written as

$$T_{inc,r} = \tau_r \min[\max\{\tau_{rc} I_{h'>s}\rho(h'-s) - \tau_{rd}, 0\}, \underline{\tau}],$$

where τ_r is a separate tax rate for rental income. Notice that this formula produces 0 in rental income tax for renters.

To compute the comprehensive taxes, we first obtained the consolidated income. Then, we deducted the social insurance premium and a portion of mortgage interest payments and applied a comprehensive tax rate. The consolidated income $CInc$ consists of financial and rental income that exceeds $\underline{\tau}$ plus labor earnings:

$$CInc = \max[ra - \underline{\tau}, 0] + \max[\max\{\tau_{rc} I_{h'>s} \rho(h' - s) - \tau_{rd}, 0\} - \underline{\tau}, 0] + wz$$

The consolidated income is taxed at a rate of τ_c after the τ_m th fraction of the mortgage interest payments and the social insurance premium $T_{inc,si} = \tau_{si} CInc$ are deducted. The comprehensive taxes are written as follows:

$$T_{inc,c} = \tau_c \max[(1 - \tau_{si}) CInc - \tau_m r_m m, 0]$$

Thus, all included, income tax and the social insurance premium $T_{inc}(w, z, r, a, \rho, h', s)$ can be written as follows:

$$T_{inc}(w, z, r, a, \rho, h', s) = T_{inc,si} + T_{inc,c} + T_{inc,f} + T_{inc,r}$$

To simplify the problem, we assume that the government collects transaction costs and taxes and uses them for its expenditures in a way that does not affect individual decisions.

2.5. The Individual Household's Problem and Equilibrium

We write the individual household's problem recursively. Let $V(z, h, m, a)$ be the value function of a household with productivity z, housing stock h, mortgage borrowing m, and financial assets a who chooses the consumption of nondurable goods c, shelter services s, housing stock h', mortgage borrowing m', and financial assets a', where the variables with primes are carried over to the next period. Applying the economic conditions described in the previous section to the constraints, we write the problem as follows:

$$V(z, h, m, a) = \max_{c, h', s, m', a'} u(c, h', s) + \beta \phi E\{V(z', h', m', a') \mid z\},$$

subject to

$$\begin{aligned}
&c + a' + (1 + r_m) m + I_{h>0, h' \neq h} T_s + I_{h'>0, h' \neq h} T_b + T_{inc} + I_{h'>0} T_h + \delta p h' \\
&\qquad \leq wz + (1 + r) a + m' + \rho(h' - s) + p(h - h'), \\
&m' \leq \mu p h', \\
&\frac{(1 + r_m)^n r_m}{(1 + r_m)^n - 1} m' \leq \nu\{wz + ra + I_{h'>s} \rho(h' - s)\}, \\
&m' \geq 0, \\
&a' \geq 0, \\
&h' \geq s > 0 \quad \text{if} \quad h' > 0.
\end{aligned}$$

The stationary equilibrium consists of a set of prices (p, ρ), a set of policy rules $\{h'(z,h,m,a), s(z,h,m,a), m'(z,h,m,a), a'(z,h,m,a), c(z,h,m,a)\}$, a value function $V(z,h,m,a)$, and a probability measure of households $\lambda(z,h,m,a)$ such that (i) the policy rules and value function solve the individual household's problem stated above, (ii) the probability measure is stationary, and (iii) prices are consistent with the following market clearing conditions:

$$\int h' d\lambda = H,$$
$$\int s d\lambda = H.$$

Note that the first condition states that the total housing stock owned by all the households in the economy is equal to the fixed housing supply H, and the second condition implies that the total housing stock H, including rental houses, is used as shelters for households.

III. Calibration

The model described in section II was used to quantitatively evaluate the effects of economic fundamentals on real house prices, rent, and welfare in the Korean economy over the period from 2001 to 2016. To this end, we parameterized two model economies, each reflecting the economic environments of 2001 and 2016 in Korea.

3.1. Economic Fundamentals and Policy Parameters

We consider the following exogenous economic fundamentals and policy factors: (i) real interest rates on savings and mortgage, (ii) average household nonasset income, (iii) housing stock (supply) in the economy, (iv) the LTV ratio limit, (v) the DTI ratio limit, (vi) property possession tax, and (vii) property acquisition tax. Table 1 summarizes these parameters, and the sources of these parameters are explained below in detail.

[Table 1] Parameters for Economic Fundamentals and Policy Factors

		Year 2001	Year 2016
Real Interest Rate on Savings (%)	r	4.07	0.90
Real Interest Rate on Mortgage (%)	r_m	5.63	2.18
Real Average Household Nonasset Income (million won)	w	36.52	44.35
Housing Supply ($10m^2$)	H	6.147	7.013
LTV Ratio Limit	μ	1	0.7
DTI Ratio Limit	ν	1	0.6
Effective Property Possession Tax Rate (%, in 2001 house price)	τ_h	0.14∼0.38	0.12∼0.17
Effective Property Possession Tax Rate (%, in 2016 house price)		0.14∼0.51	
Effective Property Acquisition Tax Rate (%)	τ_b	1.78	1.1∼2.4

(Real Savings and Mortgage Rates) We used the weighted average savings and mortgage rates of deposit banks collected by the Bank of Korea. We converted them into real rates by subtracting the inflation rate based on the consumer price index. The savings and mortgage rates are, respectively, 4.07% and 5.63% for 2001 and 0.9% and 2.18% for 2016.[4]

(Real Average Household Income) We mapped households' average total income[5] in the Household Income and Expenditure Survey to the average labor earnings in the model. The average nonasset income for 2016 is 44.35 million won, and we inflated the 2001 nonasset income using the consumer price index to obtain 36.52 million won.[6]

(Housing Supply) For the 2016 housing supply, we used the average size of residential properties from the Korea Housing Survey, which is 70.13. The housing supply in 2001 is set to 61.47 m^2.

(LTV and DTI Ratio Limits) The Financial Services Commission tightened the maximum LTV ratio to 70% in August 2014, and the value was the same rate in

[4] To smooth out the interest rate changes we observed in the data, we averaged the 1999 to 2001 rates to use for the 2001 rates in the model and the 2014 to 2016 rates for the 2016 rates. While the data for savings rates are available from January 1999, the mortgage rate is only available from August 2001. We extrapolated the mortgage rates between January 1999 and July 2001 using the average spread between deposits and loans.

[5] Property income is excluded when computing households' average total income.

[6] The current version of the Household Income and Expenditure Survey provides the average income of households only from 2006. To obtain the 2001 value of average household income, we calculated backward using the income growth rate in the old version of the survey.

2016. We set the LTV ratio limit to 0.7 for 2016 in the model. For 2001, on the other hand, when there was no regulation on the maximum LTV ratio, we assumed that households could borrow against their entire house value and thus set the LTV ratio limit to 1. Similarly, the DTI ratio limit was set to 0.6 for 2016, which was the value for the capital-metropolitan region in 2016, and the value is 1 for 2001, when the regulation was absent.

(Effective Property Possession Tax Rate in 2016) In 2016, property possession tax consists of (i) property tax (local tax) and (ii) comprehensive real estate holding tax (national tax).

The tax base for the property tax (local tax) is 60% of the total value of the house at the standardized market price. The property tax is progressive, ranging from 0.1% to 0.4%, and there are three types of surtax: local education tax (20% of the property tax liability); city planning tax (0.14% of the tax base); and region development tax, which is progressive and applied to the value of the housing structure. Table 2 shows the progressive tax brackets for property tax and region development tax.

[Table 2] 2016 Property and Region Development Tax

	Tax Brackets (million won)	Tax Rate
Property Tax	below or equal to 60	0.1%
	(60, 150]	0.15%
	(150, 300]	0.25%
	above 300	0.4%
Region Development Tax	below or equal to 6	0.04%
	(6, 13]	0.05%
	(13, 26]	0.06%
	(26, 39]	0.08%
	(39, 64]	0.10%
	above 64	0.12%

The tax base for comprehensive real estate holding tax (national tax) is 80% of the total value of the house at the standardized market price, if the house is owned by a person who exceeds tax-exempt thresholds. The tax-exempt thresholds are 900 million won for owner-occupiers and 600 million won for landlords. The comprehensive real estate holding tax is progressive, with its rate ranging from 0.5% to 2%, and the surtax is an extra tax for rural areas, which is 20% of the tax liability. Table 3 presents the progressive tax brackets for comprehensive real estate holding tax.

[Table 3] 2016 Comprehensive Real Estate Holding Tax

Tax Brackets (million won)	Tax Rate
below or equal to 600	0.5%
(600, 1200]	0.75%
(1200, 5000]	1%
(5000, 9400]	1.5%
above 9400	2.0%

To apply such complicated real estate taxes to the model, we proceeded as follows. First, we discretized the sizes of housing and shelter services into square meter(m^2), $h' \in \{60, 90, 120, 150, 180, 210, 240\}$, and $s \in \{30, 60, 90, 120, 150, 180, 210, 240\}$. Second, we assumed that the standardized market price (tax base) per unit size was 70% of the actual transaction price per unit size[7] and that the housing structure took up 31.4%[8] of the total house value. Third, using a house price of 32.26 million won per $10\,m^2$ in 2016, we applied the above tax system to all feasible combinations of h' and s in the model. The effective property tax rate in the model economy of 2016 ranges from 0.12% to 0.17%, depending on the size of the housing stock and whether the household is that of a landlord.

(Effective Property Possession Tax Rate in 2001) In 2001, property possession tax consisted of (i) property tax for the housing structure and (ii) general land tax.

[Table 4] 2001 Property and Common Facilities Tax

	Tax Brackets (million won)	Tax Rate
Property tax	below or equal to 12	0.3%
	(12, 16]	0.5%
	(16, 22]	1%
	(22, 30]	3%
	(30, 40]	5%
	above 40	7%
Common facilities tax	below or equal to 5	0.06%
	(5, 10]	0.08%
	(10, 20]	0.1%
	(20, 30]	0.12%
	(30, 50]	0.14%
	above 50	0.16%

[7] The real transaction price is the equilibrium price in the model, and the standardized market price is used to compute taxes.

[8] We assume the same for the 2001 economy. The procedure to obtain this value is described when we compute the 2001 property possession tax.

The tax base for the property tax is the total house value at the standardized market price. The property tax is progressive, ranging from 0.3% to 7%, and there are three types of surtax: local education tax (20% of the property tax liability); city planning tax (0.2% of the tax base); and common facilities tax, which is progressive and applied to the tax base. Table 4 shows the progressive tax brackets for property tax and common facilities tax.

The tax base for general land tax is 32.4% of the land value, accessed at the official land price. This tax is also progressive, with the rate ranging from 0.2% to 5%, and is subject to three types of surtax: local education tax (20% of the general land tax liability); city planning tax (0.2% of the tax base); and a special tax for rural areas that is progressive and is applied to the general land tax liability. Table 5 presents the progressive tax brackets for general land tax and the special tax for rural areas.

[Table 5] 2001 General Land Tax and Special Tax for Rural Areas

	Tax Brackets (million won)	Tax Rate
General land tax	below or equal to 20	0.2%
	(20, 50]	0.3%
	(50, 100]	0.5%
	(100, 300]	0.7%
	(300, 500]	1%
	(500, 1000]	1.5%
	(1000, 3000]	2%
	(3000, 5000]	3%
	above 5000	5%
Special tax for rural areas	below or equal to 5	0%
	(5, 10]	10%
	above 10	0.16%

We incorporated the tax system into the 2001 model. Specifically, we set (i) the value of the housing structure relative to that of the land on which the house is situated, (ii) the ratio of the actual transaction price relative to the standardized market price for the housing structure, and (iii) the ratio of the actual transaction price relative to the official land price for the land. First, using the 2001 house price per unit size as reported by KB Real Estate and the 2001 value of new buildings from the Ministry of Construction & Transportation, we set the value of housing structures to 31.4% of the total house value. Second, we set the housing structure value at the standardized market price to 30.3% of that of the real transaction price, which was taken from the 2001 value of housing structures in the basis price relative to that of new buildings. Third, we followed Ro (2003) for the ratio of the real transaction price relative to the official land price for the land. The effective property tax rate in the 2001 model ranges between 0.14% and 0.38%, depending on

the size and ownership type.

(Property Acquisition Tax) In 2016, households were required to pay three types of taxes when buying a house: property acquisition tax, a special tax for rural areas, and local education tax (we lumped these taxes together and called it "property acquisition tax"). We assumed that households reported the value of the house by the actual transaction price when they traded houses and set that as the tax base. Table 6 shows how these tax rates vary depending on the size and the price of houses. Applying the abovementioned rates, we obtained the effective property acquisition tax rate in the 2016 model economy, which ranges from 1.1% to 2.4%.

[Table 6] Property Acquisition Tax Rate in 2016

House price (million won)	Size (m^2)	Property acquisition tax	Special tax for rural areas	Local education tax
below or equal to 600	below or equal to 85	1	0	0.1
	above 85	1	0.2	0.1
(600, 900]	below or equal to 85	2	0	0.2
	above 85	2	0.2	0.2
above 900	below or equal to 85	3	0	0.3
	above 85	3	0.2	0.2

In 2001, households paid four types of taxes when they bought a house: property acquisition tax, a special tax for rural areas, registration tax, and local education tax. These rates are flat: 2%, 0.2%, 3%, and 0.6%, respectively. We followed Ro (2003) and set the tax base as 33.5% of the house value at the actual transaction price for property acquisition tax and the special tax for rural areas, and 30.8% for registration tax and local education tax. Putting these taxes together, the property acquisition tax in the 2001 model economy was a flat rate of 1.78%.

3.2. Parameters Common Across 2001 and 2016 Model Economies

This section explains parameters commonly used in both the 2001 and 2016 model economies. One set of the parameters was taken from the literature, and the rest were calibrated within the model to match the data moments.[9]

[9] For the second set of parameters, we matched our model to the data in 2016 mainly because more data are available for 2016.

[Table 7] Parameters Taken Outside (Common Between Models)

Definition	Parameter	Value
Risk aversion	σ	2
Housing stock held ($10\,m^2$)	h'	$h' \in \{0, 6, 9, 12, 15, 18, 21, 24\}$
Own shelter services ($10\,m^2$)	s	$s \in \{3, 6, 12, 15, 18, 21, 24\}$
Labor productivity persistence	ρ_z	0.8
Labor productivity innovation variance	σ_z^2	0.354^2
Probability of death	$1-\phi$	1/60
Mortgage maturity (years)	n	15
Threshold income level for separate taxation (10 mil. won)	$\underline{\tau}$	2
Separate tax rate for financial income (%)	τ_f	15.4
Separate tax rate for rental income (%)	τ_r	0
Ratio of rental income tax base relative to rental income	τ_{rc}	0.4
Rental income deduction (10 mil. won)	τ_{rd}	0.4
Social insurance premium rate (%)	τ_{si}	8.41
Marginal tax rate for comprehensive taxation (%)	τ_c	6.6∼41.8
Tax deduction for mortgage interest payments (%)	τ_m	100
Effective brokerage commission for selling a house (%)	τ_s	0.4∼0.5
Effective brokerage commission for buying a house (%)	$\tau_{b,1}$	0.4∼0.5

(Parameters Taken from Outside) Table 7 summarizes parameter values set outside of the model. We took a standard value of 2 for risk aversion. For the parameters of the productivity process, ρ_z and σ^2, we took the values of 0.8 and 0.354^2 respectively, following Chang and Kim(2008). Labor productivity was discretized over seven equally spaced grid points, as in Tauchen(1986). Following Kim(2010), we set the mortgage maturity to 15 years.

[Table 8] Comprehensive Income Tax Rate in 2016

Tax Brackets (million won)	Tax Rate
below or equal to 12	6.6%
(12, 46]	16.5%
(46, 88]	26.4%
(88, 150]	38.5%
above 150	41.8%

We took and simplified Korea's 2016 income tax code. All financial and rental income less than a threshold value ($\underline{\tau}$) of 20 million won was separately taxed. The

separate tax rate for financial income τ_f was set to 15.4% and 0 for the rental income.[10] The tax base for rental income is 40% of the rental income after a 4-million-won deduction (τ_{rc} and τ_{rd}). The tax base for the comprehensive income tax was obtained by deducting the social insurance premium and mortgage interest payments from the consolidated income. The social insurance premium rate was 8.41%,[11] and we assumed that the mortgage interest payments were fully deducted. Table 8 shows the comprehensive income taxation in Korea as of 2016 which we fed into the model.

We use the brokerage commission rate posted by the Korea Association of Realtors in 2016, summarized in Table 9.

[Table 9] Brokerage Commission Rate in 2016 from the Korea Association of Realtors

House Value (million won)	Commission Rate	Maximum Commission (million won)
below 50	0.6%	0.25
[50, 200)	0.5%	0.80
[200, 600)	0.4%	
[600, 900)	0.5%	
above or equal to 900	0.5%	

(Internally Calibrated Parameters) We now explain the parameters determined internally by matching target data moments. As we did with the other parameters common across 2001 and 2016 models, we set these parameters by matching the model and data in 2016. The target data moments and calibration results are summarized in Table 10.

The preference parameter for nondurable goods relative to one's own shelter services α and the house depreciation rate δ directly affects the equilibrium house price and rent by changing the housing demand. The utility costs of landlords[12] mainly control the share of the landlords in the model, and the discount factor directly affects the average LTV ratio by changing the borrowing behavior of households. Table 10 shows that the model precisely captures most of the data

[10] As of 2016, rental income less than 20 million won for landlords who are not officially registered as operating their own rental business is not effectively taxed.

[11] Social insurance in Korea consists of four national insurances: the national pension, health insurance, long-term care insurance, and unemployment insurance. As of 2016, workers are responsible for paying 8.41% of their consolidated income for these insurances.

[12] The utility costs of holding multiple properties can be interpreted as both pecuniary and non-pecuniary costs of managing rental properties, collecting rent, and paying realtor fees whenever a new tenant moves in. Also, there is an extra tax burden for owning multiple properties, which is implicitly embedded into the utility costs.

moments.[13]

[Table 10] Calibrated Parameters and Data Moments

Definition		Value	
Preference for nondurable goods relative to own shelter services	α	0.850	
House depreciation rate	δ	0.00361	
Utility cost of landlords	χ	0.00930	
Discount factor	β	0.978	
Variable		2016 Model	2016 Data
House price (10 million won/$10m^2$)		3.226	3.226
Rent (10 million won/$10m^2$)		0.1061	0.1061
Share of homeowners		0.642	0.560
Share of landlords		0.145	0.143
Average LTV ratio of homeowners		0.148	0.148

3.3. Further Validation of the Model

Given that we calibrated the parameters common across 2001 and 2016 using the 2016 data, we further validate our model by comparing the model moments not targeted in the calibration. Table 11 shows another set of data moments in 2016 that we did not aim to match in the calibration. The corresponding model figures in the steady state are reported accordingly.

[Table 11] Untargeted Statistics in the Steady State

	2016 Model	2016 Data
Share of homeowners with mortgage	0.790	0.698
Average ratio of house price/total income (homeowners)	6.994	8.484
Average ratio of rent/total income (renters)	0.135	0.140
Average ratio of mortgage/total income (homeowners)	1.050	1.499
Average ratio of net wealth/total income (all households)	4.367	6.676

The statistics in the column denoted by the 2016 data are from the Korea Housing Survey. The share of homeowners holding mortgage debt is 0.70 in the

[13] The sources used to compute the data moments are as follows. We used 2016 average house price per $10m^2$ from KB Real Estate. For the rent, considering households in Jeonse contracts as the renters, we used the conversion rate for Jeonse to rent from the Korea Appraisal Board and computed the average annual rent of Jeonse households per $10m^2$. Then, using the shares of households that live in Jeonse contracts and those paying monthly rent from Korea Housing Survey, we computed the weighted average of annual rent per $10m^2$, which is 1.06 million won. Statistics of House Ownership shows that the share of homeowners is 56% and that of landlords is 14.3%. The average LTV ratio of homeowners is from the 2016 Korea Housing Survey.

data, and the model generates a similar number–about 0.79. The remaining four moments are house prices, rent, mortgage debt, and the net wealth of households relative to their income. Note that the average income in the model was calibrated to match that from Household Income & Expenditure Trends, in which the average income is 29% is higher than that in the Korea Housing Survey. We argue that if we take this into account, the moments from the 2016 model would be broadly similar to the data moments.[14]

[Table 12] Housing Distribution in 2016: Model vs Data

		Size of own shelter services(s) (in m^2)								
		30	60	90	120	150	180	210	240	sum
Housing stock held(h') (in m^2)	0	20.80	13.98	0.00	0.00	0.01	0.00	0.00	0.00	34.77
	60	0.22	23.35							23.57
	90	0.15	1.38	18.39						19.92
	120	0.16	1.90	0.00	6.10					8.16
	150	0.02	0.16	0.22	0.00	0.42				0.83
	180	0.00	0.23	3.14	0.00	0.00	0.92			4.29
	210	0.08	0.05	2.58	0.00	0.00	0.00	0.67		3.37
	240	0.00	0.14	2.89	1.21	0.00	0.00	0.00	0.85	5.09
	sum	21.43	41.19	27.22	7.30	0.42	0.92	0.67	0.85	100
2016 data	sum	21.58	34.33	30.34	10.46	2.31	0.77	0.15	0.07	100

In Table 12, we compare the distributions of housing stock held(h') and one's own shelter services (s, living space in m^2) from the model to those in the 2016 Korea Housing Survey.[15] Most of the households live in a house less than 90 m^2.

We also checked the residence type distribution and average living space by labor income. The first column in Table 13 is the seven grid points of labor earnings as calibrated in the model, and the rest of the columns show the share of households in each residence type and the average living space by income group. In the model, the share of renters decreases in earnings. The model also predicts that households own larger or more houses as their earnings increase. We also observe this pattern in the data, and the distributions of the model and the data are comparable, except for the lowest- and highest-earning groups.

[14] A simple way to see this is to deflate the data statistics by 29%. Then, the statistics are, in the order shown in the table, 6.02, 0.1, 1.06, and 4.74.

[15] Note that the data does not provide the joint distribution of h' and s. We only compared the marginal distribution of s to that of living space in the data.

[Table 13] Housing Distribution by Earnings: Model vs Data

Labor earnings (mil. won)	2016 Model				2016 Data			
	Distribution of residence type conditional on labor earnings			Average size	Distribution of residence type conditional on labor earnings			Average size
	Renters	Owner-occupiers	Landlords		Renters	Owner-occupiers	Landlords	
7.55	74.2	16.8	9.0	38.4	44.4	51.6	4.0	59.6
13.63	62.5	24.9	12.6	43.3	53.2	43.8	3.0	58.4
24.58	45.5	37.0	17.5	54.2	51.9	45.0	3.1	62.2
44.35	36.5	50.1	13.4	69.2	31.1	62.5	6.4	78.0
80.00	22.0	65.3	12.7	82.9	18.8	68.9	12.3	94.3
143.32	4.7	77.0	18.2	107.3	13.3	62.9	23.9	113.1
260.35	0.0	81.5	18.5	140.2	24.1	60.8	15.2	85.0
Average	35.8	49.9	14.3	70.1	40.1	54.5	5.4	70.1

Note that the model economy abstracts from the ages of households and the heterogeneity in the local differences of houses. For this reason, the model does not account for a relatively large share of the retired elderly households with low income that own relatively large houses in the data. Also, in reality, some of the households with the highest labor earnings live in Seoul or the capital area, where houses are expensive, and thus ending up renting houses.

IV. Effects of Economic Fundamentals on House Prices and Rent

In this section, we report the main results. First, we describe the 2001 and 2016 model's steady states and present the model's predictions about the changes in housing prices and rent relative to what we observed over the same period. Second, given the steady state results, we describe our counterfactual experiments that show the contributions of each economic fundamental to the price changes and welfare.

4.1. 2001 and 2016 Model Steady States

Recall that our model economy was calibrated to match the 2016 data moments, including house prices and rent. The 2001 model economy was obtained by computing the model again with the 2001 economic fundamentals, as documented in section III. In this process, the prices in 2001 were not targeted, and the question is whether the model can generate the 2001 prices we observe in the data. Table 14 shows the relevant housing statistics from the model and the data for 2001 and 2016.

In the data, the average real house price increased by 27.6%, from 25.27 in 2001

to 32.26 in 2016. Similarly, the model predicted that the house price would increase by 34.8%, from 23.93 to 32.26 over the same period. The model also forecast the change in real rent reasonably well: The model predicted a 2.5% decrease in real rent between 2001 and 2016, similar to the data counterpart of a 2.1% decrease in real rent. The model-generated rent–price ratio closely aligns with what we observed in 2001: 4.55% in the model versus 4.29% in the data.

[Table 14] Relevant Housing Statistics: Model vs Data

	Model		Data	
	2001	2016	2001	2016
House price (10 million won/$10m^2$)	2.393	3.226	2.527	3.226
Rent (10 million won/$10m^2$)	0.1088	0.1061	0.1083	0.1061
Rent/House price	0.1455	0.0329	0.0429	0.0329
Share of homeowners	0.771	0.642	0.542	0.560
Share of landlords	0.077	0.145		0.143
Average LTV ratio (homeowners)	0.037	0.148		0.148
Share of homeowners with mortgage	0.193	0.790		0.698
Average ratio of house price/total income (homeowners)	4.293	6.994		8.484
Average ratio of rent/total income (renters)	0.133	0.135		0.140
Average ratio of mortgage/total income (homeowners)	0.178	1.050		1.499
Average ratio of net wealth/total income (all households)	6.030	4.367		6.676

Note: In the model economy, net wealth is defined as the sum of housing stock value and the financial asset net of mortgage borrowing. In the data, it is calculated with "total asset (Q52_4)" and "total debt (Q53_1_4)" from the 2016 Korea Housing Survey.

Homeownership in the model decreased from 77.1% in 2001 to 64.2% in 2016, while the corresponding figures from the data are almost flat, rising from 54.2% in 2001 to 56% in 2016. It is likely that the missing Jeonse contracts in the model could have led to the model assuming more homeownership because the households that would have lived in Jeonse contracts if the contract had been allowed are counted as "homeowners" in the model. Also, the wide gap between the model and the data in 2001 suggests that the real costs of living under Jeonse contracts in 2001 were possibly lower than those associated with owning or renting houses.[16]

Unfortunately, microdata for the rest of the variables in Table 14 are not available for 2001. Although we cannot observe these statistics directly from the data, it is possible to evaluate the overall changes in these variables in a qualitative sense. In reality, we know that household debt and the house price have increased much faster than income growth over the last 15 years. Then, it is natural to expect that

[16] The real house price increased by 27.6%, the price of the Jeonse contract increased by 29.5%, and the real monthly rent decreased by 19.8% from 2001 to 2016. This implies that the effective costs of living under Jeonse contracts were lower in 2001. Furthermore, this inference is consistent with the fact that the share of households living under Jeonse contracts was 28.2% in 2001 and 15.5% in 2016.

the share of landlords, the average LTV ratio, the share of households with mortgage debt, the house price–income ratio, and the mortgage debt–income ratio have all increased, which is what the model predicted for the period between 2001 and 2016. Furthermore, the model showed a stable rent–income ratio. The model also predicted that the net wealth–income ratio would decrease because a lower rate of returns on savings and higher income reduces the incentive to accumulate wealth for precautionary motives.

[Table 15] Variables by Income Group in the 2001 Model

Labor earnings (mil. won)	2001 Model			
	Average housing stock held	Average size of own shelter services	Average nondurable consumption	CEV, relative to 2016 (%)
6.22	41.2	45.2	1935	-4.1
11.22	48.2	48.4	2300	-4.1
20.25	54.0	54.4	2750	-4.4
36.52	59.0	60.6	3297	-4.1
65.89	69.0	67.2	3916	-3.5
118.86	83.5	80.3	4745	-2.1
214.43	107.2	103.2	5896	-0.7
Average	61.5	61.5	3358	-4.0

Note: The change in welfare was measured by consumption equivalent variation. The interpretation of -4% CEV is that the level of average welfare in the 2001 model economy can be achieved with only 96% of the life time consumption in the 2016 model economy.

Tables 15 and 16 show the welfare changes implied by the model over the years. The welfare changes are measured by consumption equivalent variation (henceforth, CEV): that is, how much of the lifetime consumption in the 2016 model economy needs to be compensated in order to be equivalent to the 2001 model economy, which differs in terms of the economic and political environment. First, the average welfare increased for all groups in 2016. With higher income and a larger housing supply, households should be able to enjoy the overall welfare gains in general in 2016. Second, the welfare of the two lowest income groups increased even though their own shelter services and nondurable goods consumption decreased in 2016, because some households in these groups changed from being landlords to renters, no longer paying the utility costs of being landlords. Also, in 2016, more houses were owned by higher-income groups. Third, for the rest of the income groups, their shelter services and nondurable goods consumption both increased, which denotes a significant increase in welfare.

[Table 16] Variables by Income Group in 2016 Model

Labor earnings (mil. won)	2016 Model Average housing stock held	Average size of own shelter services	Average nondurable consumption
7.55	23.1	38.4	1700
13.63	34.5	43.3	2185
24.58	53.3	54.2	2786
44.35	66.6	69.2	3492
80.00	84.9	82.9	4264
143.32	124.0	107.3	5177
260.35	164.6	140.2	6207
Average	70.1	70.1	3543

4.2. Counterfactual Experiments

In this section, we quantify the contribution of each economic factor to the changes in the house prices, rent, and welfare by replacing one exogenous factor in the 2016 model with the corresponding one from 2001. A series of exercises are performed one by one for all seven economic changes observed over the years: the decrease in real interest rates, the increase in real income, the increase in house supply, the tightening of the LTV limit, the tightening of the DTI limit, the decrease in property possession tax, and the changes in property acquisition tax, the calibration of which is all described in section III. Table 17 summarizes the results.

Over the period from 2001 to 2016, the model predicted a 34.8% appreciation of the real house price and a 2.5% decrease in rent.[17] Table 17 shows the contribution of each factor to the predicted price changes. For example, the decrease in real interest rates alone would predict a 30.5% increase in the real house price and an 8.6% decrease in the real rent. The house price and rent changes are mostly attributed to the decrease in real interest rates, the increase in real income, and the increase in house supply, with impacts of +30.5%, +16.8%, and -14.6% for the house price and -8.6%, +21%, and -13.1% for the rent, respectively. On the other hand, the changes in housing-related regulations (the LTV and DTI limits) and real estate taxes turn out to have only marginal effects on the prices, contrary to the common belief that these policies significantly affect the house price and rent.

[17] The data counterparts are a 27.6% increase in the real house price and a 2.1% decrease in the real rent, reported in Table 14.

[Table 17] Contributions of Each Economic Changes to House Prices and Rent

Economic Factors	House price	% Change	Rent	% Change
Decrease in real interest rates	2.472	30.5	0.1161	-8.6
Increase in real income	2.763	16.8	0.0877	21.0
Increase in house supply	3.776	-14.6	0.1221	-13.1
Tightening LTV regulation	3.334	-3.2	0.1075	-1.3
Tightening DTI regulation	3.269	-1.3	0.1048	1.2
Decrease in property possession tax	3.150	2.4	0.1037	2.3
Change in property acquisition tax	3.195	1.0	0.1064	-0.3
Overall Change	2.393	34.8	0.1088	-2.5

Below, we explain the effects of each economic factor to the housing market, along with the economic mechanism behind the results.

4.2.1. The Effects of the Decrease in Real Interest Rates

Table 18 reports the overall changes of the real savings rate decreasing from 4.07% to 0.9% and the real interest rate on mortgages decreasing from 5.63% to 2.18%. In this case, the house price increased by 30.5%, from 24.72 to 32.26, and the rent decreased by 8.6%, from 1.161 to 1.061. The decrease in interest rates is the most significant factor to explain the increase in the house price and the second-largest source of the decrease in rent.

[Table 18] The Effects of the Decrease in Real Interest Rates on House Price and Rent

	2001 real interest rates + 2016 economic fundamentals	2016 Model
Real savings rate (%)	4.07	0.90
Real mortgage rate (%)	5.63	2.18
house price (10 mil. won/$10m^2$)	2.472	3.226
Rent (10 mil. won/$10m^2$)	0.1161	0.1061
Rent/house price	0.0470	0.0329
Share of homeowners	0.765	0.642
Share of landlords	0.062	0.145
Average LTV of homeowners	0.032	0.148

The reduction in the interest rate on mortgage increased housing demand. Also, with a lower interest rate, households could readjust their portfolio from financial assets to real estate. These rises in the housing demand increased the house price and the share of landlords, resulting in a fall in rent. The lower interest rates prevented households from accumulating financial wealth. With higher house prices, the share of homeowners fell. The distribution of housing became more concentrated toward the rich, who took out larger mortgage loans, resulting in a substantial increase in the LTV ratio among homeowners.

The decrease in the real interest rates reduced the aggregate welfare by 16.7%, measured by CEV.[18] Nondurable goods consumption and welfare decreased for all income groups, and the size of shelter services decreased for the three lowest income groups because the lower interest rates made it hard to accumulate wealth, especially for low-income households. The lower rates led to the increase in the house price and the fall in nondurable goods consumption, resulting in significant welfare loss.[19]

4.2.2. The Effects of the Increase in Labor Earnings

Table 19 reports the overall changes of labor earnings increasing by 21.4% from 36.52 to 44.35. The house price increased by 16.8%, from 27.63 to 32.26, and the rent increased by 21.0%, from 0.877 to 1.061. The increase in earnings is the factor with the second-largest effect on the house price and constitutes the most important source of changes in rent.

[Table 19] The Effects of the Increase in Labor Earnings on House Price and Rent

	2001 Labor Earnings + 2016 economic fundamentals	2016 Model
Labor earnings (mil. won)	36.52	44.35
house price (10 mil. won/$10m^2$)	2.763	3.226
Rent (10 mil. won/$10m^2$)	0.0877	0.1061
Rent/house price	0.0317	0.0329
Share of homeowners	0.635	0.642
Share of landlords	0.163	0.145
Average LTV of homeowners	0.146	0.148

Higher earnings increased the demand for both consumption goods and shelter services. Also, the precautionary accumulation of wealth (or houses) against the idiosyncratic income risk decreased in earnings under the CRRA preference. As a result, (i) the overall rise in demand for houses increased the house price and the share of homeowners, and (ii) the share of landlords decreased due to the smaller precautionary motive, which in turn reduced the supply of rental houses, resulting in the rise in rent.

With higher earnings, the aggregate welfare increased by 16.5%. It is worth mentioning that the richest reduced both their housing stock held and their own shelter services. The former is due to the decrease in the precautionary motive, and

[18] Welfare changes by income group for each counterfactual experiment discussed in Section 4.2 are reported in the Appendix.

[19] For high-income groups, one's own shelter services increased, which could improve welfare. However, the model predicts that the negative effects of less nondurable goods consumption dominated.

the latter implies that the substitution effect dominated the income effect.[20]

4.2.3. The Effects of the Increase in House Supply

Table 20 reports the aggregate changes of the housing supply increasing from 61.47 to 70.13, measured by the average living space. The house price decreased by 14.6%, from 37.76 to 32.26 and the rent decreased by 13.1%, from 1.221 to 1.061. The increase in housing supply is the factor with the third-largest impact on the house price changes in absolute value and constitutes the second-largest impact on the absolute change in rent.

[Table 20] The Effects of the Increase in Housing Supply on House Price and Rent

	2001 House Supply + 2016 economic fundamentals	2016 Model
House Supply ($10m^2$)	6.147	7.013
house price (10 mil. won/$10m^2$)	3.776	3.226
Rent (10 mil. won/$10m^2$)	0.1221	0.1061
Rent/house price	0.0323	0.0329
Share of homeowners	0.617	0.642
Share of landlords	0.168	0.145
Average LTV of homeowners	0.139	0.148

In equilibrium, the house price fell further than the rent. As a result, the share of homeowners increased, with a rise in the average LTV. The share of landlords decreased because lower rent forced landlords to sell their rental units. The aggregate welfare increased by 2.1%, and the consumption of shelter services increased for all income groups.

4.2.4. The Effects of the tightening of the LTV Limit

Table 21 shows the overall changes of the borrowing limit under the LTV regulation being tightened from 100% to 70%. The house price decreased by 3.2%, from 33.34 to 32.26, and the rent decreased by 1.3%, from 1.075 to 1.061.

In contrast to the economic factors discussed above, the changes in tax schemes and housing-related policies such as the LTV and DTI regulations we observed between 2001 and 2016 turn out to have little impact on house prices, rent, and welfare.

[20] The increase in earnings induced a higher demand for both nondurable goods and shelter services (the income effect). On the other hand, the rise in the house price in equilibrium had a substitution effect such that households consumed more nondurable goods and less shelter services.

[Table 21] The Effects of Tightening of the LTV limit on House Price and Rent

	2001 LTV regulation + 2016 economic fundamentals	2016 Model
Upper limit of LTV	1	0.7
house price (10 mil. won/$10m^2$)	3.334	3.226
Rent (10 mil. won/$10m^2$)	0.1075	0.1061
Rent/house price	0.0323	0.0329
Share of homeowners	0.670	0.642
Share of landlords	0.129	0.145
Average LTV of homeowners	0.168	0.148

With a tightened LTV limit, households whose outstanding loans were higher than 70% of their property value needed to downsize. With this decrease in housing demand, the house price fell. However, the number of households directly affected by this LTV tightening turns out to be relatively small, resulting in a limited effect on the house price.[21] The houses were purchased by wealthy households who did not have to take out loans and who converted the properties into rental houses. Thus, the overall homeownership decreased, and the share of landlords increased. In the rental market, the increase in supply turned out to be larger than the increase in demand, and the rent fell.

The average welfare increased marginally by 0.2% with a tighter LTV limit. The tightened LTV limit lowered the living costs by decreasing house prices and rent. On the other hand, households needed to accumulate more financial assets to purchase houses. For low-income groups, the latter effect dominated, resulting in a small welfare loss. High-income groups, on the other hand, benefited from the former, and their welfare increased, albeit by a small percentage, given the marginal changes in house prices and rent.

4.2.5. The Effects of the Tightening of the DTI Limit

Table 22 shows the overall changes of the borrowing limit of the DTI limit being tightened from 100% to 60%. The house price decreased by 1.3%, from 32.69 to 32.26, and the rent increased by 1.2%, from 1.05 to 1.06.

[21] Since we targeted the effective LTV of homeowners at 14.8% in 2016 model economy, tightening the LTV limit would not have much of an effect on the house price until the limit is close to 14.8%. If we further restricted the upper limit from 0.7 to 0.4, the house price would decrease by an additional 3.1%, still a modest amount. Tightening the LTV limit from 0.4 to 0 (no borrowing) would decrease the house price by an additional 12.0%, generating a sizable level of change.

[Table 22] The Effects of Tightening the DTI Limit on House Price and Rent

	2001 DTI regulation + 2016 economic fundamentals	2016 Model
Upper limit of DTI	1	0.6
house price (10 mil. won/$10m^2$)	3.269	3.226
Rent (10 mil. won/$10m^2$)	0.1048	0.1061
Rent/house price	0.0321	0.0329
Share of homeowners	0.618	0.642
Share of landlords	0.148	0.145
Average LTV of homeowners	0.160	0.148

With the tightened DTI limit, some low-income homeowners downsized their home or moved to a rental property, and some low-income landlords were forced to sell their properties, which decreased the housing demand and house prices. Also, the increase in the demand for rental houses raised the rent. The houses for sale were likely to be purchased by households with a high income due to the tighter DTI limit. The homeownership among higher-income groups increased. As a result, the share of homeowners increased, while the share of landlords decreased. Also, the average LTV decreased, since it became harder for low-income groups to borrow due to the tightened DTI limit.

Nondurable goods consumption and average welfare increased for all labor earnings groups in 2016, even though the welfare gain was only 0.4%. Low-income landlords sold their rental properties, saving the utility costs of managing multiple properties. High-labor-earning groups benefited from the increase in rental income, which increased their welfare.

4.2.6. The Effects of the Decrease in Property Possession Tax

Table 23 reports the overall changes of the effective property possession tax rate decreasing from 0.14–0.51% to 0.12–0.17%.

[Table 23] The Effects of the Decrease in Property Possession Tax on House Price and Rent

	2001 Property Possession Tax + 2016 economic fundamentals	2016 Model
Property Possession Tax (%)	0.14∼0.51	0.12∼0.17
house price (10 mil. won/$10m^2$)	3.150	3.226
Rent (10 mil. won/$10m^2$)	0.1037	0.1061
Rent/house price	0.0329	0.0329
Share of homeowners	0.640	0.642
Share of landlords	0.149	0.145
Average LTV of homeowners	0.151	0.148

The house price increased by 2.4%, from 31.50 to 32.26, and the rent increases by 2.3%, from 1.048 to 1.061. The reduction in property tax had similar effects to the increase in labor earnings for homeowners as well as for renters as potential home buyers. Thus, the qualitative interpretation of the results in this section is similar to that of section 4.2.2.

Welfare increased by 0.4%. Most of the welfare gains were concentrated in wealthy households because the tax cut was more substantial for expensive properties.

4.2.7. The Effects of the Changes in Property Acquisition Tax

Table 24 reports the overall effects of the effective rate of property acquisition tax changing from a flat 1.78% to a range of 1.1%–2.4%. The house price increased by 1.0%, from 31.95 to 32.26, and the rent decreased by 0.3%, from 1.064 to 1.061. Overall, the aggregate demand for houses increased, which increased the house price and the share of homeowners.

[Table 24] The Effects of the Changes in Property Acquisition Tax on House Price and Rent

	2001 Property Acquisition Tax + 2016 economic fundamentals	2016 Model
Property Acquisition Tax (%)	1.78	1.1∼2.4
house price (10 mil. won/$10m^2$)	3.195	3.226
Rent (10 mil. won/$10m^2$)	0.1064	0.1061
Rent/house price	0.0333	0.0329
Share of homeowners	0.641	0.642
Share of landlords	0.143	0.145
Average LTV of homeowners	0.142	0.148

The effective rate of property acquisition tax decreased for small houses and increased for large houses. Thus, the share of households with small houses increased, which decreased the utility costs of landlords on average and increased the supply of rental properties. At the same time, some renters bought small houses with the tax cut, which raised the average LTV.

Although the average welfare barely changed, the low-income groups experienced small welfare gains of 0.2%. They benefited from lower rent and a lower acquisition tax rate. While there could be welfare losses for the rich due to the higher acquisition tax rate, it turns out that very few rich households changed house sizes, resulting in little changes in their welfare.

V. Conclusion

In this paper, we quantitatively evaluated the effects of macroeconomic fundamentals and housing-related policies on real house prices, rent, and household welfare in Korea. We employed a model of heterogeneous households with incomplete markets, where the optimal choice of households endogenously determines house prices and rent. After validating the model with a calibration process, we measured the counterfactual price and welfare changes in response to changes in the macroeconomic fundamentals and housing-related policies: changes in the real interest rate, the real household income, the aggregate house supply, borrowing constraints such as the LTV and DTI limits, property tax, and acquisition tax.

The results are as follows. First, with the macroeconomic fundamentals and policies observed over the period 2001–2016 in Korea, the model explains the changes in house prices and rent in the data reasonably well. While real house prices increased by 27.6% and real rent decreased by 2.1% in the data, the model predicted a 34.8% increase and a 2.5% decrease, respectively. Second, in the counterfactual experiments, we showed that the observed changes in real house prices and rent were mostly attributed to the decrease in the real interest rate, the increase in real income, and the increase in aggregate house supply. Conversely, housing-related policies used over the period turned out to have little impact on the price changes. Third, the average welfare improved over the years in the model, but each factor had different impacts on household welfare. While the decrease in the real interest rate sparked welfare loss due to the consumption drop driven by the higher house prices, the increase in real income and aggregate house supply turned out to enhance welfare. The tightened LTV limit worked in favor of high-income groups, while the tightened DTI limit improved the welfare of most households except for the lowest-income groups. Also, high-income groups benefited from the decrease in the property tax rate, but the acquisition tax rate change benefited the groups with low labor earnings.

Our results, however, should not be interpreted to suggest that housing-related policies such as the LTV and DTI regulations and tax changes are ineffective. Instead, our findings imply that the magnitude of changes in these policies over the years was not large enough to affect the housing market significantly. The decrease in the real interest rate reduced the cost of borrowing in 2016 to 40% of the cost in 2001, the real labor earnings increased by 21%, and the aggregate house supply increased by 14.1%. On the other hand, for instance, even though the LTV limit was tightened from 100% to 70%, most households were not directly affected by this change because the actual LTV on average is merely 14.8%. It is the same case with the tightening of the DTI limit. Also, the changes in property and acquisition taxes were minor relative to the changes in real labor earnings. Thus, our results suggest

that housing-related policies are likely to be more effective when they target a specific group of households or regions that are directly affected by the policies.

Our work contributes to the literature by adding a comprehensive model of the Korean tax code and housing-related policies in order to provide a better understanding of the house price and rent changes in Korea over the period from 2001 to 2016. Nevertheless, the model still has some limitations. First, our work exclusively focuses on the long-term effects by comparing two different steady states. Thus, our results cannot explain year-to-year variation in the housing market. Second, we did not address potentially important issues such as local differences in house prices generated by amenities, Jeonse contracts in housing choices, or bequest motives. No demographic changes are addressed in our model. We leave these issues for future research.

Appendix: Additional Tables

[Table A.1] The Effects of the Decrease in Real Interest Rates on Welfare

	2001 real interest rates + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	44.8	48.3	2253	17.9	23.1	38.4	1700
13.63	53.4	53.3	2692	16.6	34.5	43.3	2185
24.58	61.0	60.6	3245	16.1	53.3	54.2	2786
44.35	67.3	66.7	3894	16.4	66.6	69.2	3492
80.00	79.5	80.8	4614	17.0	84.9	82.9	4264
143.32	97.7	96.3	5649	18.3	124.0	107.3	5177
260.35	127.1	126.9	7115	19.6	164.6	140.2	6207
Average	70.1	70.1	3965	16.7	70.1	70.1	3543

Note: The change in welfare was measured by consumption equivalent variation. In this experiment, the households in the 2016 model economy need to be compensated with 16.7% more life-time consumption on average in order to achieve the same level of welfare in the counterfactual economy.

[Table A.2] The Effects of the Increase in Labor Earnings on Welfare

	2001 Labor Earnings + 2016 economic fundamentals				2016 Model		
Labor earnings (group)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
$z=1$	24.5	38.6	1429	-16.5	23.1	38.4	1700
$z=2$	35.3	43.0	1846	-16.4	34.5	43.3	2185
$z=3$	53.6	53.3	2350	-16.4	53.3	54.2	2786
$z=4$	66.5	68.9	2933	-16.6	66.6	69.2	3492
$z=5$	84.5	83.7	3585	-16.4	84.9	82.9	4264
$z=6$	123.7	110.1	4366	-16.2	124.0	107.3	5177
$z=7$	172.6	146.6	5205	-16.2	164.6	140.2	6207
Average	70.1	70.1	2981	-16.5	70.1	70.1	3543

[Table A.3] The Effects of the Increase in Housing Supply on Welfare

	2001 House Supply + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	19.6	35.4	1740	-3.2	23.1	38.4	1700
13.63	30.5	39.0	2238	-2.2	34.5	43.3	2185
24.58	53.4	45.9	2843	-2.0	53.3	54.2	2786
44.35	66.2	59.4	3540	-2.1	66.6	69.2	3492
80.00	84.2	76.3	4261	-2.3	84.9	82.9	4264
143.32	122.7	93.1	5179	-2.5	124.0	107.3	5177
260.35	172.4	121.3	6182	-2.4	164.6	140.2	6207
Average	61.5	61.5	3578	-2.1	70.1	70.1	3543

[Table A.4] The Effects of the Tightening of the LTV Limit on Welfare

	2001 LTV regulation + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	24.5	38.6	1709	0.0	23.1	38.4	1700
13.63	33.4	43.8	2214	0.2	34.5	43.3	2185
24.58	52.2	54.2	2809	0.0	53.3	54.2	2786
44.35	66.8	68.8	3502	-0.3	66.6	69.2	3492
80.00	86.1	83.4	4286	-0.4	84.9	82.9	4264
143.32	121.8	106.8	5192	-0.6	124.0	107.3	5177
260.35	183.5	139.6	6181	-0.7	164.6	140.2	6207
Average	70.1	70.1	3561	-0.2	70.1	70.1	3543

[Table A.5] The Effects of the Tightening the DTI Limit on Welfare

	2001 DTI regulation + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	35.8	38.7	1664	-0.5	23.1	38.4	1700
13.63	53.2	42.8	2168	-0.3	34.5	43.3	2185
24.58	65.7	53.4	2776	-0.5	53.3	54.2	2786
44.35	85.9	69.4	3470	-0.5	66.6	69.2	3492
80.00	86.1	83.2	4245	-0.2	84.9	82.9	4264
143.32	123.8	109.0	5148	-0.4	124.0	107.3	5177
260.35	161.8	139.9	6188	-0.2	164.6	140.2	6207
Average	70.1	70.1	3525	-0.4	70.1	70.1	3543

[Table A.6] The Effects of the Decrease in Property Possession Tax on Welfare

	2001 Property Possession Tax + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	22.9	39.0	1671	0.0	23.1	38.4	1700
13.63	34.1	45.9	2159	0.0	34.5	43.3	2185
24.58	53.1	54.7	2779	0.1	53.3	54.2	2786
44.35	66.6	69.8	3492	0.0	66.6	69.2	3492
80.00	85.3	82.3	4275	0.0	84.9	82.9	4264
143.32	123.8	103.0	5219	-0.2	124.0	107.3	5177
260.35	164.6	131.5	6295	-0.7	164.6	140.2	6207
Average	70.1	70.1	3546	-0.4	70.1	70.1	3543

[Table A.7] The Effects of the Changes in Property Acquisition Tax on Welfare

	2001 Property Acquisition Tax + 2016 economic fundamentals				2016 Model		
Labor earnings (mil. won)	Housing Stock held	Own shelter services	Nondurable consumption	Welfare changes (%)	Housing stock held	Own shelter services	Nondurable consumption
7.55	23.2	39.1	1687	-0.2	23.1	38.4	1700
13.63	34.1	43.5	2181	-0.2	34.5	43.3	2185
24.58	53.5	53.7	2775	-0.2	53.3	54.2	2786
44.35	66.7	68.9	3491	-0.1	66.6	69.2	3492
80.00	85.2	84.2	4255	0.0	84.9	82.9	4264
143.32	121.8	105.8	5185	0.0	124.0	107.3	5177
260.35	169.3	146.7	6180	0.0	164.6	140.2	6207
Average	70.1	70.1	3538	0.0	70.1	70.1	3543

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