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ORIGINAL PAPER

Impacts of demand and supply-side interventions on South Korea's housing markets: a dynamic housing-CGE analysis

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Abstract
This paper examines the impacts of housing market policies in Korea by developing a dynamic computable general equilibrium model integrating regional housing markets and multiregional mobility. We compare simulation outcomes of demand- and/or supply-side approaches in housing market interventions and address how these various policy instruments affect housing prices, demand, and household welfare. Policy simulation results suggest that supply-based interventions would be more effective than housing tax policies for cooling down overheated housing markets without decreasing consumer welfare. Tax-based demand-side approaches result in a 1.8–2.2% housing price drop and a 1.1–1.2% welfare decline annually between 2021 and 2024. In the supply-side policy, investing in housing construction leads to 3.4–4.1% lower housing prices and 1.5–1.8% enhanced welfare.

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1 Introduction

Overheated housing markets have emerged as a global challenge after the 2007–2008 global financial crisis. Notably, in 2020, Seoul, the capital of South Korea, experienced a 26.1% surge in housing prices, considerably higher than the average increase rate of 7.4% across 150 world cities (Knight Frank's Global Residential Cities Index 2021). This spike in Seoul's housing prices initiated debates over the role of the government in the housing market because housing comprises the largest share of national wealth (the net worth of the total economy) in Korea.[1] Government interventions in such a context are crucial as they significantly impact prices, ownership, demand and supply, and the overall economic landscape. Since the early 2000s, the effectiveness and efficiency of housing policies have been a subject of intense debate among politicians and policymakers due to Seoul's persistent housing market bubble.[2] To curb rising housing prices, the South Korean government (2017–2022) announced 25 sets of real estate measures focused on fiscal and financial tactics and tried to dampen excessive demand in the housing market.

The government's intervention in housing markets through taxation may be used to repair housing market failures while also increasing government revenues. Imposing higher tax rates increases the actual cost and financial burden of homeownership, and doing so may act as a price effect and decrease excessive demand for homes without manipulating housing prices. Specifically, the South Korean government adjusted tax rates on real estate and capital gains and introduced a new tax.[3] These tax measures were designed to induce multi-home owners to sell their excess homes and to discourage property speculation, which was expected to trigger a sharp decline in housing prices.

Despite these efforts, housing prices did not stabilize, leading to an unanticipated housing boom in Seoul. This inverse reaction in the market raised questions among policymakers and researchers: why do housing prices continue to rise despite increased financial burdens on homeownership? Previous studies have offered empirical explanations of housing tax effects on housing demand, using comparative static analysis and a partial equilibrium approach, but have reported inconsistent findings. Many studies show that increasing the tax burden lowers housing prices and the volume of housing transactions. However, some studies (Dachis et al. 2011; Petkova and Weichenrieder 2017; Bai et al. 2014; Du and Zhang 2015) report inconsistent findings on the expected effects of housing policies based on the stated assumptions and methods. Researchers have pointed out that this ambiguity or inconsistency in the findings may result from ignoring housing supply, endogenous

[1] Real estate accounted for roughly 75% of assets and 55% of national wealth in 2020 (Statistics Korea and Bank of Korea 2021). It is relatively high considering real estate accounted for approximately 33% of national wealth of the United States (Eggleston et al. 2020).

[2] Particularly, from 2017 to 2021, the sale price of apartments or condominiums in Seoul increased by 75% (Korea Real Estate Board 2002).

[3] The short-term (fewer than 2 years) capital gains tax is set at 40–70% for multi-home owners. In addition to a high property tax rate, in 2005, the government introduced the comprehensive real estate tax, a type of progressive wealth tax, on high-value homes.

prices, and other macroeconomic variables. It suggests that a general equilibrium approach in a dynamic setting should be considered to address this issue.

Another possible explanation may be that property owners, especially those with multiple homes, rent out their second or investment homes and transfer increased costs to renters. This shift can lead to higher rents, pushing renters toward homeownership and boosting demand. With low-interest rates, annual rent (long-term housing rental deposits[4]) in the Seoul Metropolitan Area (SMA) has risen significantly, and the cost of renting has become effectively the same as the cost of owning a home (Shin and Yi 2019). In fact, the increase in first-time home buyers worsens the housing market with insufficient housing supply. SMA has experienced increasing demand but has limited housing stock and new home supply because this area has more regulated land use, such as green belt zoning.[5]

South Korea has recently faced two major challenges in its housing market: an increase in speculative investment and a shortage of affordable homes. People have questioned the effects of demand-side policies with housing tax that the government focused on so far. Consequently, supply-side policies have received greater attention. Supply-side intervention in the housing market focuses on providing affordable housing and increasing homeownership rather than cooling the housing market.[6] However, this supply-side policy has been little considered in previous studies to address housing market issues.

In light of the complexities of the housing market, this paper examines the impacts of housing market policies through the development of a dynamic housing computable general equilibrium (dynamic H-CGE) model. This model aims to capture housing demand and supply, prices, user costs, and household welfare through interactions among various economic agents and industrial activities. The housing market is disaggregated into four heterogeneous submarkets, allowing interregional mobility of households as housing consumers. By simulating demand- and supply-side interventions, we seek to address how these policy instruments affect the housing market and household welfare. The H-CGE model can help policymakers gain a holistic perspective on how housing policies are linked to various markets and economic activities.

[4] Long-term housing rental deposit (or security deposit system) called the "Jeonse" is common tenure in the South Korean real estate market. To lease a house, tenants put up a lump sum deposit typically worth as much as 40–70% of the house's market value, then live without paying monthly rent for two years (Ryu and Kim 2018). At the end of the lease term, the landlord returns the full amount.

[5] Since 1971, the green belt zoning has been common land use control tool in South Korea and more actively implemented to Seoul Metropolitan Area (SMA) aimed at curbing rapid urban sprawl. Due to the housing supply shortages and housing price inflation, the government initiated significant reforms to the green belt policy and released green belt land in SMA for residential development during 2000s (Jeon 2019).

[6] For instance, South Korea's Two Million Housing Drive project implemented the construction of over 2.1 million units from 1988 to 1992 (Feather 2019). In response to a 1980s severe housing shortage caused by sharply increasing housing demand, the South Korean government introduced a policy to provide more affordable housing on a mass scale. The government developed land for residential towns and provided tax incentives and subsidies to housing suppliers (Kim and Park 2016). This approach has been prevalent in fast-growing economies where public authorities can develop residential land for large-scale public housing.

This paper begins with a literature review of previous research on the effects of housing market intervention tools. Following this, we introduce the H-CGE model, detailing its structure and conceptual description. In the policy simulation section, we assess various demand- and supply-side intervention policies in terms of the resulting changes in housing prices, demand, and consumer welfare over the study period. The paper concludes with a summary and critical discussion of our results.

2 Literature review

Governments intervene in the housing market through various policies, such as imposing taxes to decrease excessive demand and the release of land use regulations to supply more homes to the market. The efficiency and effectiveness of housing policies are controversial in both policy debates and scholarly research. Researchers have measured the effectiveness and impact of such policies on the housing market and the economy. Consequently, the economic impact of housing market policies has been broadly studied, with most studies focusing on housing taxation, which is frequently utilized as the government's housing policy measures.

A considerable body of work across countries and sub-regions has examined housing taxes, such as imposing property taxes (Bai et al. 2014; Cao and Hu 2016; Du and Zhang 2015; Liberati and Loberto 2019; Poterba 1992), transfer/transaction taxes (Benjamin et al. 1993; Dachis et al. 2011; Davidoff and Leigh 2013; Fritzsche and Vandrei 2019; Fu et al. 2016; Guillaume and Trannoy 2017; Petkova and Weichenrieder 2017; Van Ommeren and Van Leuvensteijn 2005), or capital gains taxes (Agarwal et al. 2020; Coleman 2010). Another body of literature focuses on the effects of tax rate reduction or tax deductibility (Besley et al. 2014; Best and Kleven 2017; Hilber and Lyytikainen 2012) and of mortgage interest tax deduction (Gervais 2002; Sommer and Sullivan 2018). These studies analyze the impact of housing tax programs on the housing market using various empirical approaches (see Table 5).

While studies generally suggested that increasing the tax burden lowers housing prices and transaction volumes, there is variation in the directions and magnitudes of these effects. Many studies from developed countries have proved that transfer/transaction taxes have consistently been shown to reduce prices and transactions. In particular, Fu et al. (2016) provided empirical evidence that a transaction tax policy deters speculative trading activities in the short term by discouraging informed speculative traders in Singapore. However, recent studies on the new introduction of property tax in two cities, Shanghai and Chongqing in China, have concluded differently depending on whether to consider the home-purchase restriction. Bai et al. (2014) found that introducing a property tax without home-purchase restriction decreased the average housing price in Shanghai but increased the average housing price in Chongqing. The study by Du and Zhang (2015), considering home-purchase restrictions, showed that the property tax in Chongqing reduced the annual growth rate of housing prices; while, the property tax in Shanghai did not significantly affect prices.

Another branch of the literature on housing tax policies has studied the impact of tax reduction. Besley et al. (2014) and Best and Kleven (2017) examined the impact of the UK stamp duty holiday on housing transactions and concluded that eliminating the transaction tax led to increased housing market activity in the short term. Similarly, other scholars have studied the temporary mortgage tax credit in the US. Using a dynamic equilibrium model, Sommer and Sullivan (2018) found that repealing the mortgage interest deduction lowers house prices, increases homeownership, and improves welfare. Stroebel et al. (2016) reached similar conclusions, finding that the homebuyer tax credit raises house prices, increases transaction volumes, and negatively affects welfare. Their findings contrast with previous studies, in which eliminating the mortgage interest deduction was found to decrease homeownership (Chambers et al. 2009; Gervais 2002).

Most empirical findings show that tax policies effectively cool down the housing market, but a few studies have contrasting results. The divergence in results across studies examining similar policies can be attributed to many factors, such as geographical, economic, and regulatory conditions. Researchers have argued that empirically ambiguous or inconsistent findings are a consequence of rejecting endogenous prices, excluding housing supply, or missing other macroeconomic variables. In particular, price is endogenously determined by supply, demand, and other macroeconomic variables, which are, in turn, directly or indirectly affected by housing policies. Several empirical studies have demonstrated that housing prices are closely interrelated with macroeconomic variables (Rosenberg 2019). Therefore, the allowance of endogenous prices and inclusion of housing supply can lead to significantly different results.

Although there is a large body of evidence on the demand side of housing market responses to tax policies, housing supply as a policy tool has rarely been studied in terms of effectiveness or efficiency. This policy is not generally aimed at stabilizing the housing market, especially by decreasing housing prices. However, in the past decade, scholars have paid more attention to supply policies for housing because housing prices in some cities have significantly increased. These scholars have argued that artificial restrictions on housing supply through direct supply restriction or land use regulations have distorted the housing market (Gyourko 2009; Gyourko and Molloy 2015). Glaeser and Gyourko (2003, 2018) and Gyourko (2009) showed that restrictions on residential buildings, the regulation of zones and land use, and limits on the supply of housing are strongly correlated with artificially high housing prices houses in metropolitan areas or large coastal markets in the US. Differences in supply elasticities across regions determine the extent to which increases in housing demand result in higher prices, more housing investments, or booms and busts in housing markets (Glaeser et al. 2008, 2012; Guerrieri et al. 2013; Gyourko et al. 2013; Gyourko 2009).

Housing supply responsiveness is closely related to housing prices in the market, so consideration of the supply side of housing is necessary when examining housing policy. Nordvisk (2006) argued that the assumption of a fixed number of housing units is no longer appropriate over a longer period because prices act as signals for new construction. If observed prices exceed the cost of expanding housing stock, new construction is profitable, and the amount of housing stock increases.

Andrews et al. (2011) argued that, in the short to medium term, an increase in housing demand caused by mortgage market deregulation would translate into smaller increases in real house prices if the housing supply is sufficiently responsive. The low supply responsiveness of new housing has tended to exacerbate the price effect of changes in housing demand. As previous studies have suggested, supply responsiveness depends not only on geographical and urban characteristics but also on public policies, such as housing market regulations. Stricter land use regulation is related to a less responsive housing supply; a crucial factor determining the functioning of housing markets is the responsiveness of housing supply to changes in price signals.

The literature discussed in this section explains why general equilibrium models could be preferred over partial equilibrium models in analyzing housing market policies. Some studies have applied equilibrium models to both the supply and demand sides of the housing market to analyze housing market policies. Berkovec and Fullerton (1992) applied a static disaggregated general equilibrium model that includes owner-occupied and rental housing demand as risky assets, as well as endogenous consumption and investment decisions. Their simulation results show that taxes on owner-occupied housing would raise welfare and the overall homeownership rate, and removing the property tax or mortgage interest deduction would reduce the amount of homeownership and housing stock. Peng and Wang (2009) developed a general equilibrium model with endogenous housing quality and prices and examined the effects of reducing housing-related tax policies on housing quality/prices, land rent, and urban structure. They numerically found that housing quality and values rise as the urban fringe expands.

More recent studies using a general equilibrium model for the housing market have focused on the impact of mortgage interest tax deductions in the US. Sommer and Sullivan (2018) extended their model based on that of Chambers et al. (2009), who analyzed the relationship between the asymmetric tax treatment of owner- and tenant-occupied housing and the progressivity of income taxation. Sommer and Sullivan (2018) found that eliminating mortgage interest deduction causes house prices to decline, decreases housing consumption by the wealthy, increases homeownership by low-wealth and rent-occupied households, and improves welfare.

Their findings contrast those of previous studies that showed that removing mortgage interest deductions could depress homeownership and reduce welfare. For instance, Gervais (2002) argued that repealing the mortgage interest deduction leads to a decline in homeownership because it increases the cost of ownership but does not reduce down payments. These results are limited because house prices were kept fixed and were not endogenously determined. Floetotto et al. (2016) examined the effects of homebuyer tax credits using a heterogeneous-agent overlapping-generations general equilibrium model. Their results suggest that homebuyer tax credits temporarily raise house prices and transaction volumes but negatively affect welfare.

Over the last decade, researchers have examined the impact of demand-side policies and supply regulations and have delivered some empirical results. However, no empirical evidence exists for composite measures from both the demand and supply sides of the housing market. No studies have considered tax measures and housing supply policies simultaneously, even though fiscal intervention in the housing market should accompany supply-side deregulation. Therefore, our study contributes to the literature by developing a dynamic H-CGE model and examining the effects of composite measures on the macroeconomic system, which includes housing prices, demand, supply, tax revenue, and social welfare.

3 H-CGE model

3.1 Model structure

Housing policy impact analysis requires a holistic approach. This is because the housing market is spatially and sectorally connected to the commodity, service, land, and financial markets and due to the potential interactions with other existing policies. Public interventions targeting other sectors, such as land use, employment, and infrastructure, also indirectly affect housing markets, and the intended goal of a given housing policy may be interrupted by these unexpected interaction effects. For this reason, conventional single-equation models specialized in partial equilibrium analyses are often inappropriate for housing-policy studies, given their inability to capture the feedback and indirect effects arising from interactions among multiple sub-markets within a given economy.

There are two general equilibrium models to estimate the economy-wide effects of housing policies on the economy: the Dynamic Stochastic General Equilibrium (DSGE) model and the Computable General Equilibrium (CGE) model. The DSGE model has been employed to predict the effects of macroprudential and monetary policy shocks on the macroeconomy, utilizing Bayesian techniques, random variations to account for uncertainty and expectations, inter-temporal optimization, and business cycle fluctuations. Specifically, the DSGE model for housing markets has been established based on the framework of Iacoviello (2010) and Iacoviello and Neri (2010), encompassing macro-housing linkages among non-housing goods and housing goods producers, patient households (savers), impatient households (borrowers), banks, and nonfinancial firms. Several studies have conducted impact analyses on housing market fluctuations using modified versions of Iacoviello and Neri (2010)'s DSGE model, addressing credit constraints of housing mortgages (Lee and Song 2015), speculative investments (He and Xia 2020), monetary and macroprudential policies (Funke et al. 2018; Tan et al. 2022), housing consumption taxes and subsidies (Mora-Sanguinetti and Rubio 2014), preference and technology shocks as well as monetary instruments (Iacoviello and Neri 2010; Ng 2015; Ge et al. 2020), and rental housing taxes and services (Rubaszek and Rubio 2020).

However, DSGE models tend to oversimplify economic sectors and markets, exhibiting reduced flexibility in the specification of behavioral equations. To address these limitations, we adopt the CGE model framework, which accounts for micro-level economic interactions and spatial connections between a more extensive range of economic agents, including multiple regional households, firms, foreign sectors, and governments, across various labor and capital input markets and commodity markets over time. Furthermore, the CGE model facilitates the simulation of economic effects resulting from changes in housing tax rates, mortgage interest rates, and construction periods on multiregional economies, examining dynamic processes of the supply, acquisition, consumption, and sale of local housing goods.

This CGE model has been widely employed for the impact analysis of housing policies (e.g., Berkovec and Fullerton 1992; Bye and Avitsland 2003; Feltenstein et al. 2017; Keast 2010; Kim 2008; Kim and Ju 2003; Park et al. 2014). The merit of a CGE approach is in its framework, which overcomes the limitations of partial equilibrium analysis and allows for endogenous prices. An external shock changes the relative prices of inputs, factors, and commodities, leading the economy to a new Walrasian equilibrium. A CGE model, in which the economy's supply–demand structure and agents' market behaviors are modeled in detail, can keep track of the equilibrium by imposing a set of optimization and price adjustment structures.

To analyze Korea's housing policy, we have developed a dynamic CGE model with details of the housing sector called "H-CGE." In essence, H-CGE realistically portrays the functional and spatial linkages between the real-side economy and housing markets, and the model can assess the dynamic effects of housing policies on the economy. For this purpose, H-CGE extends to a conventional neoclassical-CGE structure to include a housing market module (Fig. 1). The neoclassical equilibrium structure of H-CGE focuses on the linkage among commodities, service, production sectors, and the revenue–expenditure balance in the government and household sectors; on the other hand, the housing market module explicitly represents housing demand, user costs, housing prices, and housing construction investments within a CGE structure. H-CGE has four subnational economies in Korea—three regions within the SMA (Seoul, Incheon, and Gyeonggi) and the rest of Korea (ROK)—and the rest of the world (ROW) (see Fig. 7). The model disaggregates the Korean economy into 13 production sectors (housing construction and housing services by each region, agriculture and mining, manufacturing, construction, real estate services, and other services), and considers four regional household groups (in Seoul, Incheon, Gyeonggi, and ROK) and one central government as economic agents.

On the supply side, firms are engaged in production, and a two-level Leontief structure is imposed to calibrate total output levels. Here, intermediate demand and value-added (the total outputs) are derived from input coefficients and the Cobb–Douglas production function of labor and capital inputs, respectively. Domestic supplies and foreign exports are distinguished in terms of production flows, and their optimal shares for each commodity are determined by a revenue maximization problem under the constant elasticity of transformation (CET) constraint. Total local demand is met with domestic production and foreign imports in terms of consumption flows. We adopt a small-country assumption for international trade and calibrate the local demand for foreign imports by solving a cost minimization problem incorporating the Armington elasticities. Meanwhile, an optimal demand set for labor and capital is determined from a conventional profit maximization problem of the producer. Finally, the Keynesian macroeconomic closure rule is applied to the labor market with a mean wage rate determined within the model.

On the demand side, we consider the other two economic agents—households and the government. Regional households have incomes from wages, returns on capital, government subsidies, and capital gains from the ROW. We determine their consumption levels for housing stock and other non-durable goods and services through the maximization of the Stone–Geary utility function. The government collects indirect taxes from producers, income taxes from regional households, and tariffs from foreign sectors and reallocates these taxes to other parts of the economy through public purchases, public investments, and household subsidies. The total savings consists of capital stock depreciation, household savings, government savings, and foreign savings and is used to purchase investment goods.

3.2 SAM and model calibration

Two primary, complementary dynamic solutions for the CGE models exist: the forward-looking (perfect foresight) approach and the backward-looking (recursive dynamic) approach. The forward-looking method identifies an optimal trajectory of consumption and savings based on comprehensive inter-temporal optimization and perfect expectations for all simulation periods. Conversely, the backward-looking approach calibrates this by employing behavioral equations of investment and consumption, as well as stock-flow analysis, which is founded on myopic and adaptive expectations (Babiker et al. 2009). Although there are trade-offs between these two methodologies with regard to computational feasibility, structural complexity, specificity in categorizing regional and industrial sectors, and rationality of economic agents, this paper opts for the backward-looking approach. This choice is motivated by its capacity to accommodate an array of policy combinations pertaining to the production and consumption of housing services, construction periods, housing taxes, and mortgage interest rates, thereby enabling the analysis of their annual impacts on regional economic activities in the long run.

H-CGE is a recursive dynamic model in which the value of every exogenous variable traces an annual historical path, and its benchmark social accounting matrix (SAM) takes 2020 as the base year. The SAM integrates an input–output table using national accounts published by the Bank of Korea and shows commodity and monetary flows across sectors, production factors, and economic agents. The SAM constructed for H-CGE consists of the following six accounts: the factor accounts for labor and capital, the household accounts for four regional households, the production accounts for 13 sectors, the government account, the capital account for saving and investment, and the ROW account.

H-CGE is composed of two time sub-systems: within-period and between-period modules. The former finds an equilibrium—or the market clearing points of quantity and price for each commodity and factor input in a perfectly competitive market—considering an economic goal with constraints for all agents; the latter runs for multiple periods using a solution derived from the within-period module, and it produces a sequential equilibrium path over time. The between-period module requires three functional adjustment processes for key parameters and variables of capital stock and population in each period: (1) updating the values of exogenous variables, such as the world commodity prices and government expenditures, (2) accumulating capital stock with investment flows, and (3) integrating net migrants into the population size. For example, under the stock-flow structure, capital stock at time t is equal to the sum of a net increase in investments between *t* and *t*-1 and capital depreciation at time *t*-1. The base year for the within-period module is set to 2020, and a follow-up parameter adjustment is enforced to replicate equilibrium conditions consistent with the SAM.

The model forms a square system of 378 equations and 539 variables (378 endogenous and 161 exogenous variables). This system of equations, in which the number of endogenous variables equals the number of constraints, is just-identified and returns a unique solution set under convexity without imposing any computational difficulties. Commodity prices are measured in relative terms to a numeraire, to which the consumer price index is applied. An external shock in the policy scenarios affects the relative prices among commodities and factors, and substitution elasticities determine changes in demand for the commodities and factors at a new equilibrium. In particular, substitution elasticities between domestic supply (demand) and international trade are essential parameters for defining the CET and Armington functions. Other parameters of the functions—such as the tax rate, input–output coefficients, and the shift/share parameters of the value added—can be derived using common equilibrium conditions for market clearance, zero profit, and income balance. Table 1 shows the elasticities used for non-housing sectors.

3.3 Housing market response to a policy shock

The H-CGE housing market module focuses on two policy variables, tax rate, and housing stock, and any changes in them from the reference levels are treated as a "shock" to the model. In the presence of a shock, the housing module simulates new equilibria for each year between 2021 and 2040 under the adaptive expectations hypothesis and recursively updates the levels of exogenous variables subject to the consumer price index (Devarajan and Robinson 2013). H-CGE imposes a fixed level of aggregate consumption across scenarios. Its housing module tracks dynamic changes in welfare and housing prices/demand in response to a given policy shock, generating an alternative inter-temporal path of economic behavior. Net policy impacts can be drawn by comparing the policy scenario simulation results with business-as-usual (BAU) levels.[7]

Both policy instruments—taxation and supply—help cool down local housing markets through different channels, as shown in Fig. 2. First, higher tax rates imposed on housing transactions and possessions lower housing prices, primarily by increasing housing user costs and thus suppressing demand for housing. Increased tax rates on residential properties in Seoul pivot down the budget line, and the new budget constraint is tangent to a lower indifference curve, representing a lower utility level. This slows down housing price inflation but will eventually reduce welfare among Seoul residents, which can be measured in compensating variation.

[7] Decomposition of the simulated results by detailed household characteristic (e.g., household income, number and value of properties owned, property holding period, or property location) is challenging because H-CGE models a single representative household for each region due to limited data availability.

Table 1 Elasticities for non-housing sectors

Activity	Parameter	Value	Sources
Production	Labor elasticity	0.049–0.759	SAM calibration
Export	Substitution elasticity between export and domestic supply	0.729–22.538	Jeong (2008)
Import	Substitution elasticity between import and domestic demand	0.380–1.940	Jeong (2008)

Theoretically, increasing the housing supply can have similar price effects to increasing tax rates but without demanding a loss of consumer welfare. In the short run, housing stock is fixed, and only second-hand properties can be supplied in the market on a limited scale. In this case, supply is inelastic to price, and the supply curve is nearly vertical, where price is quasi-independent of quantity and vice versa. In the longer term, however, housing supply becomes elastic to price changes unless there are land or zoning regulations. The provision of brand new housing units increases overall housing stock, shifts the supply curve rightward, and results in a new equilibrium with lower prices and a higher quantity in the long run. H-CGE distinguishes short-run and longer-run dynamics using a separate stock-and-flow accounting of preexisting housing stock and newly built housing units (Brueckner 2011). The magnitude of housing construction or flow is a function of housing prices and output levels reflecting the profit maximization behavior of the construction sector. However, a supply response takes time; thus, housing prices at a certain time period do not immediately change housing stock. In essence, housing supply reflects a net change in stock considering newly built and demolished units; housing stock is gradually adjusted to market demand through an interplay between flow (construction) and stock (supply to the market). The short run is, by definition, too short to initiate and complete housing construction, and housing prices are modeled to interact with the time required for construction (i.e., the speed of new housing supply). H-CGE also benchmarks Korea's situation, where the quantity of demolished old housing stock is largely determined by public policies and incentives for reconstruction or redevelopment rather than the physical condition of existing housing units.

3.4 Elasticities for the housing module

The housing market module tracks the interactions between the real-side economies and key housing economic variables, including housing demand, user costs of owners and renters, housing prices, and housing construction investment. Key parameters used in the housing market module are estimated from the econometric analyses of Eqs. (1) to (4) and are summarized in Table 2.

First, elasticities associated with the housing demand in four Korean regions are estimated from the Statistics Korea Housing Survey data for the period between 2010 and 2019. These annual sample survey data are collected from around 50,000 households and includes detailed information on household disposable income and consumption, housing loans and ownership, mobility and migration, and housing prices and rent. Following the approaches by Kim (2008) and Mankiw–Weil (1989), we specify a log-linear housing demand function, as shown in Eq. (1).

$$\ln\left(\mathrm{HD}_m\right) = \beta_0 + \beta_1 \ln\left(\mathrm{UC}_m\right) + \beta_2 \ln\left(\mathrm{PI}_m\right) + \sum_{n=1}^{N} \alpha_n X_{mn} + \beta_3 dm_{2010} + \epsilon_m \tag{1}$$

In this equation, the housing demand of household m (HD_m) is set as a function of the user cost of housing services (UC_m), permanent household income (PI_m), the number of household members belonging to age cohort n (X_{mn}), and a year dummy (dm_{2010}) (assigned 1 for the base year 2010 and 0 otherwise). α_n, β_0, β_1, β_2, and β_3 are parameters, and ϵ_m is an error term. HD_m is measured in the total floor area (m^2), and X_{mn} is defined on seven age cohorts.

The user cost (UC) included in Eq. (1) is a unit expense required to use housing services during a specific period and should be distinguished from the housing sales price (V_h), which is derived from housing stock supply and demand. Equation (2) shows that the cost differs by occupancy type ($\mathrm{UC}^{\mathrm{own}}$ for owner-occupiers and $\mathrm{UC}^{\mathrm{rent}}$ for tenants) and is a function of housing price (V_h) and monthly rent (R). Various tax rates—interest income tax (t_r), acquisition tax (t_a), property tax (t_p), and capital gain tax (t_g)—and other financial factors, such as interest rate (r^*), depreciation rate (deph), and inflation rate (g) are exogenously given. The interest rate (r^*) represents a weighted average of rates derived from housing finance loans and general mortgages, and the growth rate of housing prices (g) is set to 3.9% sourced from the KB Property Data Hub (2023). Concurrently, the prevailing interest income tax rate (t_r) is applied at 15.4%, and the depreciation rate for housing (deph), as established by Lee and Chung (2010), is quantified at 2.5%.

$$\begin{cases} \mathrm{UC}^{\mathrm{own}} = V_h\left\{\left(1 - t_r\right)r^* + t_a + t_p + \mathrm{deph} - \left(1 - t_g\right)g\right\} \\ \mathrm{UC}^{\mathrm{rent}} = V_h\left(1 - t_r\right)r^* + 12R \end{cases} \tag{2}$$

Second, elasticities associated with permanent income are estimated using Eq. (3) as a function of assets (prop_m), income (inc_m), and the age of the householder (age_m) (Kim 2008). Here, β_1 and β_2 represent assets and income elasticities of permanent income, respectively. A quadratic relationship is assumed between PI_m and age_m to reflect an empirical pattern taking an inverted U shape.

$$\ln\left(\mathrm{PI}_m\right) = \beta_0 + \beta_1 \ln\left(\mathrm{prop}_m\right) + \beta_2 \ln\left(\mathrm{inc}_m\right) + \beta_3 \mathrm{age}_m + \beta_4 \mathrm{age}_m^2 \tag{3}$$

Finally, investment-associated elasticities are estimated using a general stock-flow model of housing investment. In Eq. (4), housing investment (HI_{it}) in region i at time t is a function of the gross regional domestic product (grdp_{it}), construction material costs (defl_t), interest rate (rate_t), and housing supply in the previous year (supp_{it-1}).

$$\ln(\mathrm{HI}_{it}) = \beta_0 + \beta_1 \ln(\mathrm{grdp}_{it}) + \beta_2 \ln(\mathrm{defl}_t) + \beta_3 \ln(\mathrm{rate}_t) + \beta_4 \ln(\mathrm{supp}_{it-1}) + \beta_5 d_1 + \beta_6 d_2 + \beta_7 d_3 + \beta_8 d_1 \ln(\mathrm{grdp}_{it}) + \beta_9 d_2 \ln(\mathrm{grdp}_{it}) + \beta_{10} d_3 \ln(\mathrm{grdp}_{it}) + \beta_{11} d_1 \ln(\mathrm{rate}_t) + \beta_{12} d_2 \ln(\mathrm{rate}_t) + \beta_{13} d_3 \ln(\mathrm{rate}_t) + \epsilon_{it} \quad (4)$$

The model also includes a set of regional dummies—d_1 for Seoul, d_2 for Incheon, and d_3 for Gyeonggi—and a set of interaction terms, as well as an error term (ϵ_i). This function is estimated from a 22-year panel data set on regional housing markets (1998–2019) with 377 observations in total. The key equations of the H-CGE model are summarized in Table 3.

4 Policy simulations

4.1 Scenarios

We consider two sets of housing policy instruments as a policy shock: taxation and housing supply. Taxation aims to stabilize housing markets by reducing market demand through a price-based intervention. Its actual market effects, however, are not completely straightforward in terms of direction. For example, transaction taxes (e.g., acquisition and capital gains taxes) may help cool down housing markets by suppressing speculative demand, but they may create upward pressure on property prices by reducing housing stock for sale. Similarly, property tax may drive down property prices by negatively affecting the return on real estate investment, but it can also lead to housing price inflation if its burden is simply imputed to buyers (Holt and Shelton 1962). Alternatively, the government can respond to an overheated housing market by promoting housing supply. This quantity-based intervention has relatively consistent market effects against housing prices. In Korea, the primary housing supply channels are as follows: (i) loosening development density controls in zoning regulations, often given in terms of the floor area ratio and/or the building-to-land ratio,[8] (ii) up-zoning to permit residential development in the green belt or agricultural land, (iii) remodeling/repurposing commercial facilities for residence, (iv) new town development, (v) public-initiated urban redevelopment, and (vi) private-initiated residential reconstruction.

For our model simulation, we develop 13 policy scenarios—shown in Table 4—as well as a business-as-usual (BAU) scenario as a benchmark. All 13 policy scenarios impose a policy shock to Seoul's housing markets only without constraining Korea's other local housing markets. First, BAU is a reference case scenario, where a historically predetermined path is extended to the future period with the current housing policy framework maintained. H-CGE is calibrated to simulate historic GDP for the base year (i.e., 2020) under BAU, and it applies the base year housing policies to the period between 2021 and 2040.

Second, two policy scenarios whose titles begin with T_ are considered a tax-based policy instrument only, without supply-side interventions shown in the first

[8] The floor area ratio is defined as the ratio of the *total floor area* of a given building to the size of the lot or plot that the building is placed on. Similarly, the building-to-land ratio measures the share of the land that is used for the *ground level* (i.e., a single floor) of a given building.

two rows of Table 4. Among them, T_CO assumes a higher housing tax rate that is constant over time (0.3% above the BAU levels); on the other hand, T_IN represents a smoother policy shock where tax rates increase gradually throughout the period (0.03–0.53% above the BAU levels). As illustrated in Fig. 3a, these two likely tax-only scenarios are set to ensure an identical, cumulative sum of tax revenue increase from the BAU level during the period between 2021 and 2040 (US$35 billion). By comparing these scenarios, we test the time-distribution effects of policy shocks with comparable stringency.

Nine policy scenarios, whose titles begin with S_, impose a housing supply shock only, without any change in housing tax rates. Notations S, M, and L following S_ refer to short-run, mid-run, and long-run supply strategies, respectively. The short-run supply strategy primarily considers remodeling/repurposing, which commonly takes less than a year. The mid-run strategy embraces loosening zoning regulations, urban redevelopment, and new town development, and it assumes a mean supply cycle of 3 years. The long-run strategy supposes private-initiated residential reconstruction with a mean supply cycle of 6 years, which, in reality, can take up to 9.7 years in Seoul (Government of Seoul 2021). All nine scenarios take different supply cycles (either of S, M, or L) during the two sub-periods of Y1–Y6 and Y7–12 while sticking to S after those periods (Fig. 3b–d). For example, scenario S_ML takes M during Y1–Y6, L during Y7–Y12, and S during Y13–Y20. All these supply-only scenarios ensure an identical level of cumulative housing investment increase between Y0 and Y20 from the BAU level (US$35 billion).

The last two policy scenarios test a mixed case on which both taxation and supply shocks are simultaneously imposed. For example, T_CO + S_LL adopts policy shocks introduced in tax-only scenario T_CO and supply-only scenario S_LL at the same time.

4.2 Policy impacts on Seoul

Policy shocks in all scenarios significantly impact the market, but supply-based interventions tend to be more effective than taxation in cooling down overly heated housing markets in Seoul. Overall, tax-only scenarios, where higher tax rates are imposed on Seoul's residential properties to collect an additional cumulative tax revenue of US$35 billion between 2021 and 2040, drive down housing prices by 1.8–2.2% on the annual average, as shown in Fig. 1a. The effects of supply shocks—with a cumulative investment of US$35 billion to increase housing supply—are about twice as large as those of taxation, cutting Seoul's local housing prices by 3.4–4.1% on the annual average. In each scenario, the price effects of a given policy tend to increase over time (see Table 6). For example, if the government constantly imposes high tax rates for 20 years (T_CO), the annual mean price decreases by 1.8% during 2021–2026 (Y1–Y6), 2.3% in 2027–2032 (Y7–Y12), and 2.7% in 2033–2040 (Y13–Y20). Similarly, if housing is supplied every year (S_SS), the 1.1% price fall of the 2021–2026 period further steepens to 4.0% in 2027–2032 and 7.3% in 2033–2040. This time-augmented trend reflects the cumulative effects of a policy shock on the economy: a recursive

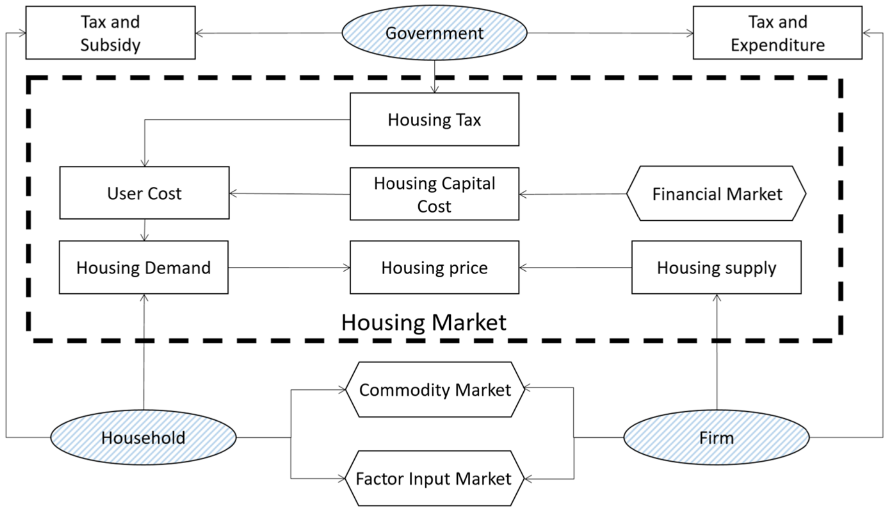

Fig. 1 Model structure of H-CGE. *Note*: Redrawn from Kim et al. (2022). The housing market module is shown within a dashed line

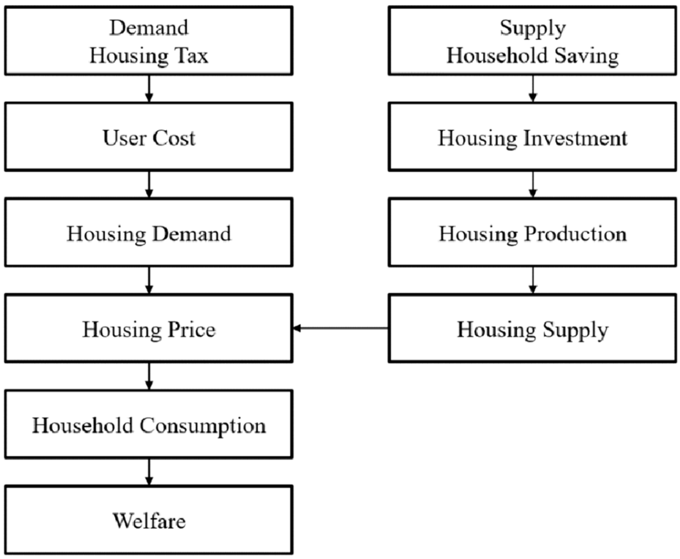

Fig. 2 Conceptual Framework of the Housing Module in H-CGE

dynamic structure taken in H-CGE emulates the reality where inefficiency arising from a market intervention at a certain time point cumulatively affects resource allocations of the following time periods.

Tax-only and supply-only scenarios have opposite effects on housing demand, in contrast to their consistent effects on housing prices (Fig. 4b). Overall,

Table 2 Elasticities Used for the Housing Module

Parameter	Seoul	Incheon	Gyeonggi	ROK	Note
Housing demand					
User cost elasticity	– 0.071	– 0.092	– 0.110	– 0.102	β_1 in Eq. (1)
Permanent income elasticity	0.532	0.379	0.414	0.368	β_2 in Eq. (1)
Permanent income					
Asset value elasticity	0.077	0.044	0.072	0.045	β_1 in Eq. (3)
Income elasticity	0.617	0.687	0.662	0.705	β_2 in Eq. (3)
Housing investment					
GRDP elasticity	1.545	1.739	1.281	0.457	β_1 in Eq. (4)
Construction cost elasticity	– 0.416	– 0.416	– 0.416	– 0.416	β_2 in Eq. (4)

All estimates are statistically significant at the 1% level

Table 3 Major equations of H-CGE model

Variable	Equation
Value-added	= CD (labor input, capital stock)
Labor input	= FOC (value-added, wage, value-added price)
Output	= LEONTIEF (intermediate demands, value-added)
Intermediate demand	= LEONTIEF (output)
Demand	= ARMINGTON (import, intra-regional demand, interregional demand)
Output	= CET (export, intra-regional supply, interregional supply)
Capital stock	= Lagged capital stock + investment
Demand	= Private non-housing consumption + private non-housing investment + government consumption + government investment + private housing consumption + private housing investment
Income	= wage + capital return + government subsidies + capital gains from the ROW
Utility	= SG (private consumption)
Private non-housing consumption	= LM (income, price)
Private housing consumption	= LM (user cost of housing services, permanent household income, the number of household members by age cohort)
Private housing investment	= LM (GRP, interest rate, the lagged housing supply)

CD Cobb–Douglas value-added function, *FOC* First-order condition of profit maximization, *LEONTIEF* Leontief production function, *ARMINGTON* Armington function, *CET* CET (Constant Elasticity of Transformation) function, *SG* Stone–Geary utility function, *LM* Linear model

increased tax rates suppress housing demand by 11.7–12.2% on the annual average, while increased housing supply drives up demand by 5.8–6.5%. This opposing effect on demand is straightforward, given that the former creates a shock to shift the demand curve inward; while, the latter shifts the supply curve outward. Despite their modest effects on housing prices ($\leq$ 2.2% on annual average), tax-based interventions introduce a relatively strong negative demand shock to

Table 4 Policy scenarios for model simulation

Scenario	Policy shock (change from the BAU level)			
	Tax Rate	Housing Supply		
		Y1–Y6	Y7–Y12	Y13–Y20
T_CO	Higher rates constant over the period	No	No	No
T_IN	Higher rates gradually increase over time	No	No	No
S_SS	No	Increased supply every year	Increased supply every year	Increased supply every year
S_SM	No	Increased supply every year	Increased supply every 3 years	
S_SL	No	Increased supply every year	Increased supply every 6 years	
S_MS	No	Increased supply every 3 years	Increased supply every year	
S_MM	No	Increased supply every 3 years	Increased supply every 3 years	
S_ML	No	Increased supply every 3 years	Increased supply every 6 years	
S_LS	No	Increased supply every 6 years	Increased supply every year	
S_LM	No	Increased supply every 6 years	Increased supply every 3 years	
S_LL	No	Increased supply every 6 years	Increased supply every 6 years	
T_CO+S_LL	Higher rates constant over the period	Increased supply every 6 years	Increased supply every 6 years	
T_IN+S_LL	Higher rates increasing over time	Increased supply every 6 years	Increased supply every 6 years	

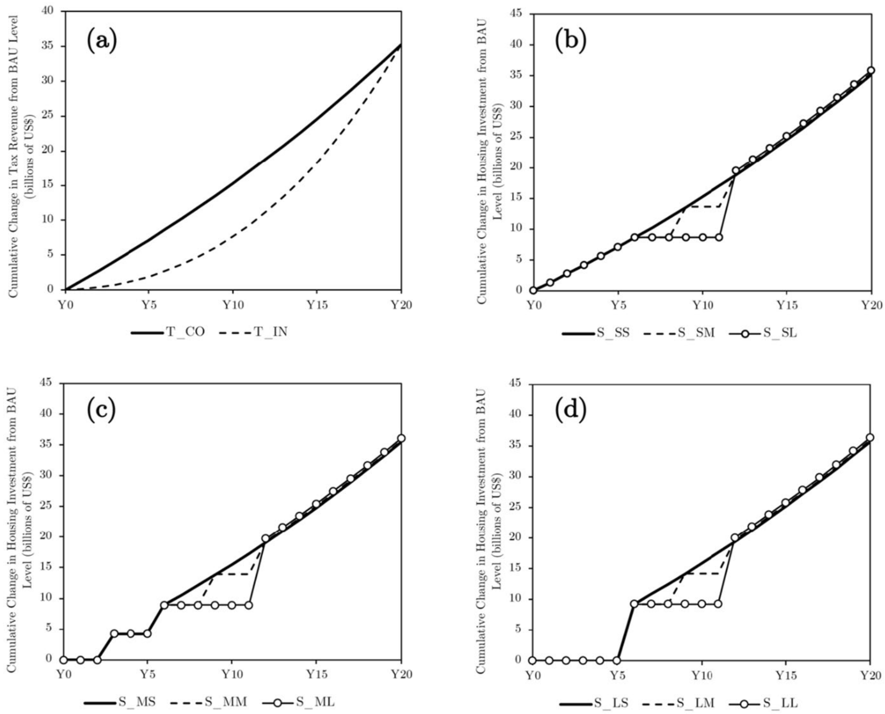

Fig. 3 Policy shock schedule: **a** tax-only scenarios; **b** supply-only scenarios with S in Y1–Y6; **c** supply-only scenarios with M in Y1–Y6; **d** supply-only scenarios with L in Y1–Y6. *Note*: The vertical axis presents Cumulative Change in Housing Investments from BAU level (billions of US $)

the market ($\leq$ 12.2%), whose magnitude tends to increase over time. In contrast, supply-based interventions maintain a relatively good balance in their price and demand effects. This result seems to reflect the fact that taxation is more distortionary and thus less efficient than supply expansion, since it in part requires the government as a resource allocator. That is, taxation presupposes the government to redistribute collected tax revenues to production sectors, which may not ensure an optimal market allocation outcome across the sectors; in contrast, supply-side interventions let the market do this job without involving the government. Theoretically, the former can incur a greater efficiency loss than the latter, given the bounded rationality of a decision maker.

Similar to their effects on demand, taxation and supply expansion also have opposite effects on welfare (Fig. 4c). Under the tax-only scenarios, overall consumption levels decline due to increased income transfer from households to the government, and reduced private consumption means a loss of welfare for Seoulites. During the period between 2021 and 2040, welfare for Seoul residents reduces by 1.1–1.2% on the annual average due to increased housing tax rates. As is the case for other results discussed earlier, such welfare costs tend to increase over time due to cumulative effects. On the other hand, Seoulites' welfare increases by 1.5–1.8% on the annual average in the supply-only scenarios.

Housing prices decline when the housing supply increases, and reduced expenditure on housing services increases the amount of disposable income available for consuming other goods and services. This would raise the levels of aggregate private consumption in Seoul, positively affecting household welfare levels. It is noteworthy that in S_LS, S_LM, and S_LL, where an increase in net housing supply does not occur until Y6, welfare slightly declines during the first 6-year period and increases after then. This is related to changes in housing prices during the same period—prices slightly increase during the first 6-year period and decline after then.

In the two mixture scenarios, net changes in price, demand, and welfare take values close to the average of the tax-only and supply-only cases. For example, in T_CO + S_LL, housing prices and demand in Seoul decline by 5.6% and 6.6% on the annual average, respectively, while household welfare increases by 0.4%. These are around the middle ground of corresponding changes in T_CO and S_LL.

One noteworthy result is related to time-distribution effects: policy shocks of a similar magnitude can have different effects depending on how they are distributed over time. Of the two tax-only scenarios, T_CO depicts a situation where a constant but relatively strong shock is imposed during the early period; while, T_IN avoids too strong a shock during the early period by gradually increasing the stringency of the shock over time. The result shows that price cooling effects are significantly greater in T_CO than in T_IN, even with a slight saving of associated welfare loss. This may speak to the importance of consistency and predictability in housing policy. That is, giving market participants a strong signal of public interventions against overly heated housing markets in a consistent and predictable manner can help the government achieve a policy goal while minimizing welfare costs. A gradual increase in the tax rate, as described in T_IN, may help avoid too strong an early shock, but increased market uncertainty related to continuously changing tax rates may introduce a larger policy compliance cost in the long run.

A similar point can also be made for supply-only cases. As explained earlier, all nine supply-only scenarios are set to ensure an identical level of cumulative housing investment during the 20-year period. The result shows that housing price cooling effects and household net-welfare gains are greater in S_SS than in any other scenario. This suggests that supply strategies aiming at a stable annual growth in the housing stock are more efficient and effective in achieving a policy goal than those targeting a lump-sum stock increase with a 3 or 6-year interval. In other words, it is important to reduce market uncertainty by sending a consistent signal on the upcoming housing supply.

5 Policy impacts on other domestic housing markets

Tax and supply policies targeting Seoul also affect other domestic markets, extending beyond Seoul's administrative boundary. First, an increase in tax rates imposed on Seoul's residential properties reduces housing demand annually by 0.5% in Incheon, 0.8% in Gyeonggi, and 0.4% in ROK (Fig. 5). A key driver

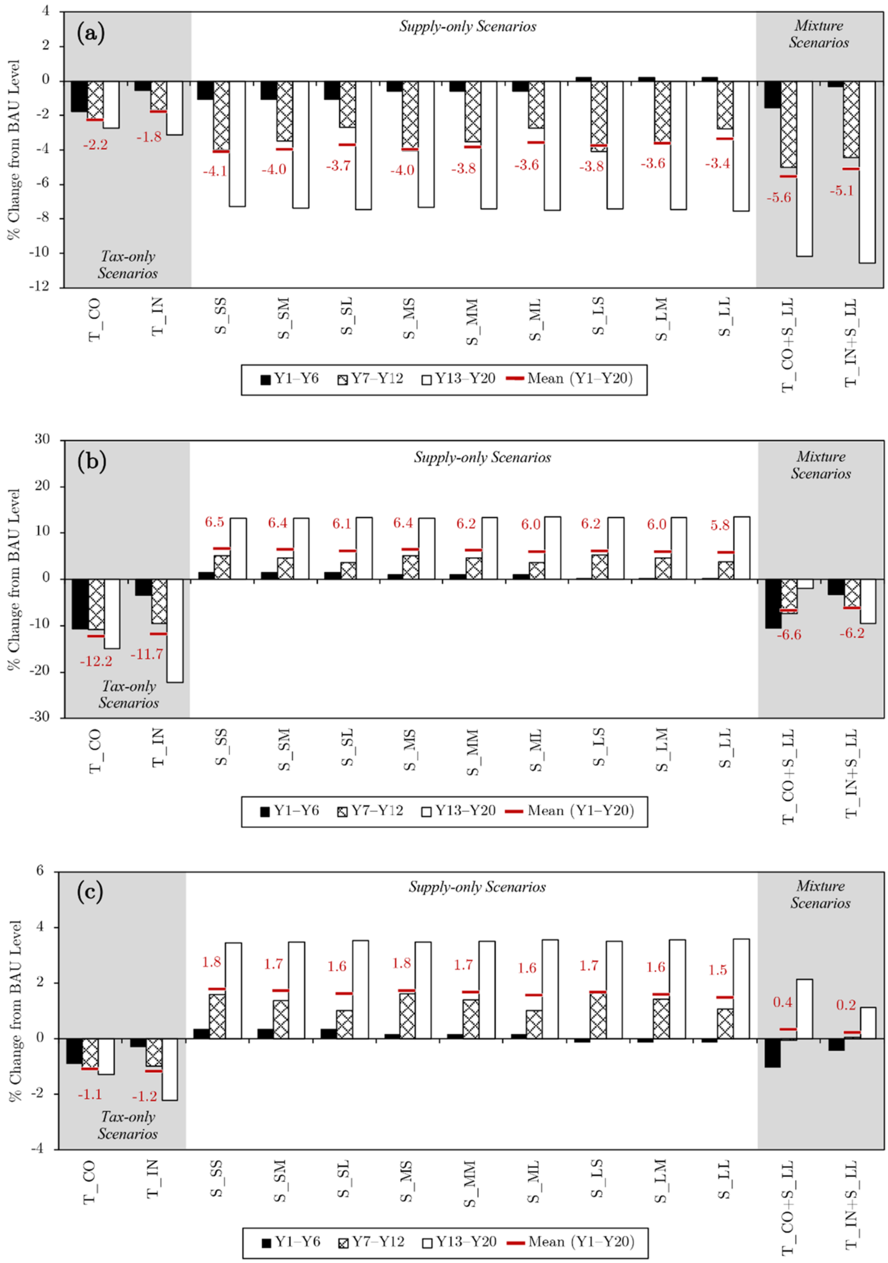

Fig. 4 Impacts on Seoul's housing markets: **a** housing prices; **b** housing demand; **c** consumer welfare

underlying this spillover effect is a cross-regional linkage in domestic housing markets arising from the spatial separation between residence and ownership. As of 2020, for example, 15.7% of residential properties in Seoul were owned

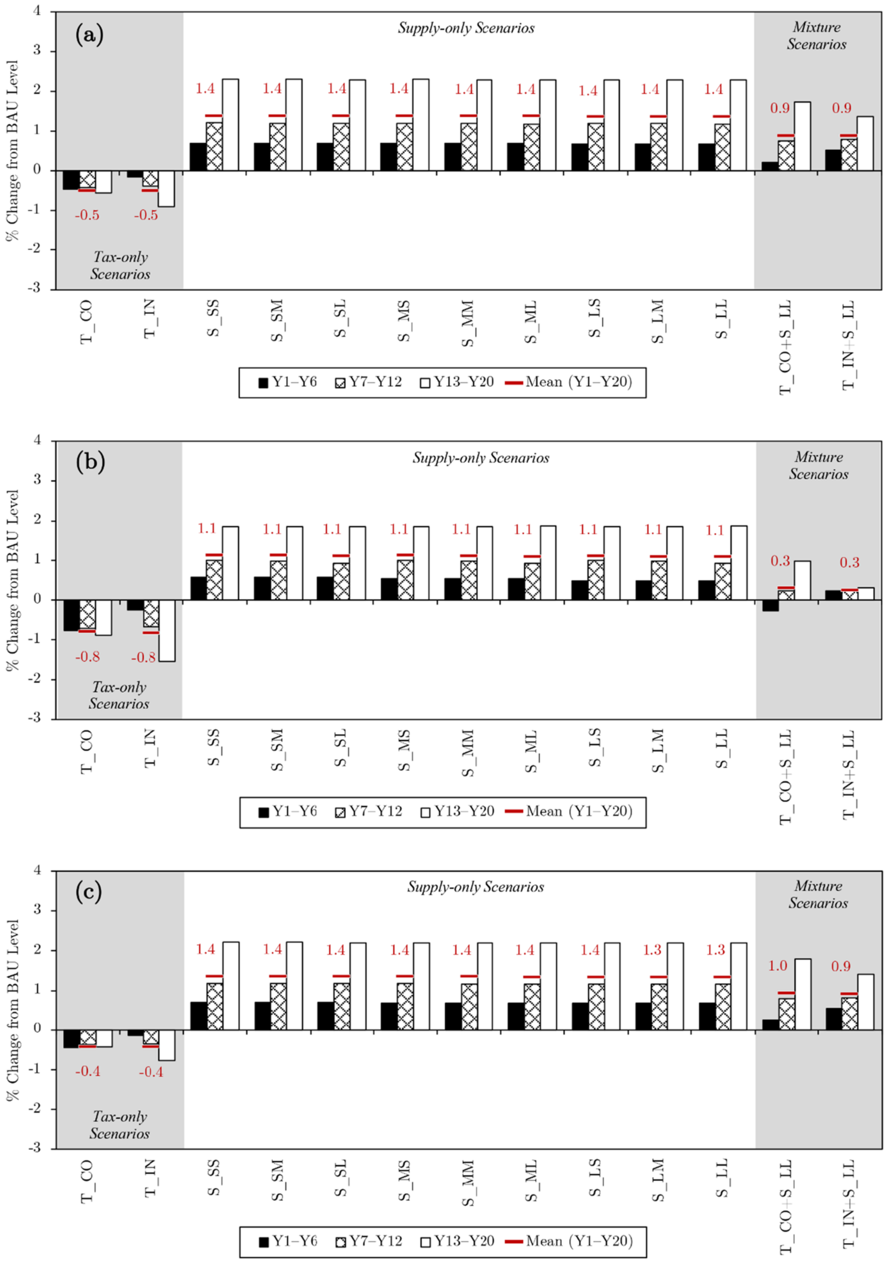

Fig. 5 Impacts on housing demand in other domestic markets: **a** Incheon; **b** Gyeonggi Province; **c** Rest of Korea (ROK)

by those residing outside Seoul (Statistics Korea 2022). Accordingly, taxation on properties in Seoul affects households' disposable income and consumption

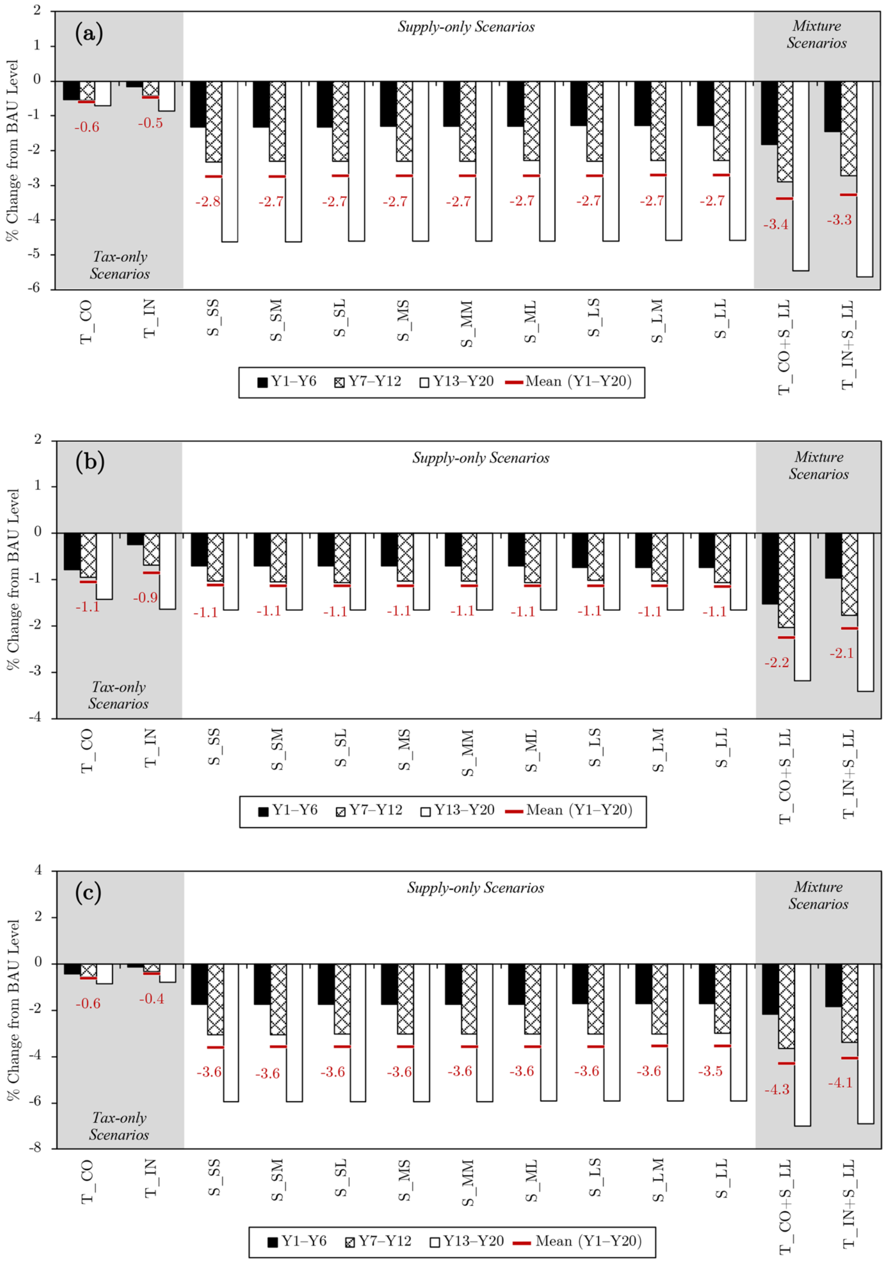

Fig. 6 Impacts on housing prices in other domestic markets: **a** Incheon; **b** Gyeonggi Province; **c** ROK

patterns in other domestic regions, including their demand for local housing services. However, the estimated spillover effects on housing demand in non-Seoul regions (≤ 0.8%) are much smaller than a ≤ 12.2% demand shock to Seoul's housing markets, presenting ≤ 6.6% of the latter in magnitude. Among the three non-Seoul housing markets, Gyeonggi is more affected by increased housing taxes on Seoul's properties than Incheon and ROK, suggesting that a relatively large fraction of Seoul's housing stock is owned by households residing in Gyeonggi.

In contrast to tax-only policies, supply-based interventions in Seoul tend to have positive effects on the housing demand in other regions. On an annual average, increased housing supply in Seoul drives up the housing demand in Incheon, Gyeonggi, and ROK by 1.4%, 1.1%, and 1.4%, respectively. This result can be explained by supply-induced price feedback and its cross-regional chain effects. As discussed earlier, housing prices in Seoul drop as local housing stock increases, and lower prices stimulate demand. Pressure for such price-led demand growth comes partly from outside Seoul and clears part of the "standby" demand for housing units in Seoul. This process necessarily introduces a downward price pressure to non-Seoul housing markets, and lower prices also drive up local housing demand outside Seoul.

In fact, housing prices in non-Seoul regions move in consistent directions (Fig. 6). Under the tax-only scenarios, housing prices in Incheon, Gyeonggi, and ROK decline on the annual average by $\leq 0.6\%$, $\leq 1.1\%$, and $\leq 0.6\%$, respectively. As discussed earlier, a relatively large price shock to Gyeonggi reflects a relatively large demand shock. Furthermore, this may suggest that Gyeonggi households own a relatively large share of the housing stock in Seoul compared to households in Incheon and ROK. Under the supply-only scenarios, the spillover effects are overall much greater. Compared with tax-based interventions, the increased housing supply in Seoul greatly impacts prices on non-Seoul housing markets, reducing prices by 2.7% in Incheon and $\leq 3.6\%$ in ROK. In Gyeonggi, the price effects are relatively moderate, showing an annual mean change of 1.1%. This may be interpreted as lower standby demand in Gyeonggi; Seoul's increased housing stock may appeal more to Incheon and ROK households—who own its smaller fraction—than Gyeonggi residents. A stronger preference for Seoul's increased housing stock can result in higher substitution effects between Seoul and local properties in Incheon and ROK, leading to greater spillover effects on local property markets in Seoul than in Gyeonggi.

In sum, interventions through both taxation and supply promotion in Seoul have significant spillover effects on local housing markets outside Seoul's administrative boundary. In particular, overall spillover effects are much greater in the supply-only scenarios than in the tax-only scenarios. One noteworthy finding is that out of the three local housing markets we consider, the spillover effects of increased tax rates in Seoul are greater in Gyeonggi; while, those of increased housing supply are greater in Incheon and ROK. As previously discussed, this seems to be associated with the relative share of Seoul's properties owned by outsiders. Such spillover effects highlight the need for careful consideration before intervening in Seoul's housing markets to avoid unnecessary side effects on local property markets.

6 Conclusion and discussion

The South Korean government has implemented various housing market policies to curb rising housing prices due to the persistent housing market bubbles since the early 2000s. Changing tax policies, including imposing heavier tax rates for multi-home owners or high-value homeowners, has been most frequently utilized as a demand-based intervention, and it was expected to trigger a sharp decline in housing prices. Supply-side policies have recently received greater attention because tax policies have not stabilized housing prices as expected. Researchers and policymakers have tried to determine effective housing market policies by measuring the economic impacts on national and local economies.

This paper assesses macroeconomic impacts according to the government's housing policy choices in housing market intervention: demand-side policies such as imposing higher tax rates, supply-side policies such as investing in residential construction, or a mixture of demand- and supply-side policies. To analyze them, we develop a dynamic CGE model that integrates the housing markets in Korea. The housing market module accounts for housing demand, investments, user costs, and multiregional migration for three sub-regions in the Seoul Metropolitan Area and the rest of Korea. We compare the simulation outcomes of the demand- and/or supply-side policies in housing market intervention and address how these various policy instruments affect housing prices, demand, and household welfare in Seoul and other regions.

The policy simulation model shows that supply-based interventions more effectively cool down overheated housing markets without decreasing consumer welfare than housing tax policies. When the government imposes higher tax rates on Seoul's residential properties, higher rates drive down housing demand by 12.2% and decrease housing prices by 1.8–2.2% on the annual average between 2021 and 2040. However, the supply shock in housing construction leads to a decline in Seoul's local housing prices by 3.4–4.1% by canceling increasing demand by increasing the housing supply twice as much as a tax scenario. In terms of welfare, housing taxes reduce the welfare of Seoul residents by 1.1–1.2% due to declining consumption levels by transferring their income to government revenue. On the other hand, Seoulites' welfare increases by 1.5–1.8% in the supply-only scenarios.

This study contributes to the existing literature by comparing housing market policies from both demand and supply perspectives. In particular, housing supply policy has rarely been examined despite recent scholarly emphasis on the significance of housing supply responsiveness or elasticities in influencing the extent to which increases in housing demand result in price. Our findings align somewhat with previous empirical studies utilizing partial equilibrium models for housing tax policies. These studies generally indicate that a heavier tax burden effectively cools down the housing market by reducing both housing prices and transaction volumes. However, our research distinguishes itself by considering endogenous prices, housing supply, and other macroeconomic variables in temporal and regional analyses and examining the market (price and demand) and macroeconomic (welfare) impacts of the supply-side policies on regional housing markets.

To address further research issues, the model should be extended into a multiregional CGE model to estimate the spillover effects of housing demand and housing production on regional economies. In this paper, housing demands and households are classified into four regions, but producers—excluding housing construction and the housing service sectors—are regarded as representative of national economic activity. Furthermore, it is important to disaggregate the housing market according to tenure choice and payment systems, such as owned housing, annually deposited rental housing, rental housing paid monthly with a deposit, and rental housing paid monthly without a deposit; our model measures user costs only by housing tenure choice. The final issue is to integrate the housing market CGE model with a financial mechanism for housing loans. Our analysis defines a house as a commodity to consume rather than an asset or property. Incorporating the expected return on housing investment with our model would enable us to examine consumer behavioral responses to government policies.

Appendix

See Tables 5, 6 and Fig. 7.

Table 5 Selected studies on the impact of housing demand policies

Housing policy	Author	Region	Effect on housing market (price and demand)
Transfer/transaction tax	Benjamin et al. (1993)	Philadelphia, US	Decrease in the sale price of residential property in Philadelphia
	Dachis et al. (2011)	Toronto, Canada	Decrease in the volume of real estate transactions and increase in land price; welfare loss
	Davidoff and Leigh (2013)	Australia	Dropping in house prices and the number of transactions in Australia
	Fritzsche and Vandrei (2019)	German states	Decrease in transactions in Germany; Enormous negative anticipation effect and fewer transactions in the long run
	Fu et al. (2016)	Singapore	Deterring speculative trading activities, rising price volatility in underpriced submarkets, and decreasing price volatility in overpriced submarkets
	Bérard and Trannoy (2017)	France	Decrease in the transactions; a loss from the total tax base
	Petkova and Weichenrieder (2017)	Germany	Decline in transactions but no effect on the price of the trade-in owner-occupied; negative price effect, but no significant effect on the transaction for apartments
	Van Ommeren and Van Leuvensteijin (2005)	The Netherlands	Decrease owner's residential mobility

Table 5 (continued)

Housing policy	Author	Region	Effect on housing market (price and demand)
Property tax	Bai et al. (2014)	Shanghai and Chongqing in China	Decrease in the average home price in Shanghai, but increase in the Chongqing
	Du and Zhang (2015)	Shanghai and Chongqing in China	No significant effect on housing prices in Shanghai; reduction of the annual growth rate of housing prices in Chongqing
	Liberati and Loberto (2019)	Italy	For owner-occupied dwellings, negative effect on the share of homeowners' property and rental prices; for second homes, opposite effects due to the shift effect
Tax Reduction/Tax deductibility/Tax credits	Besley et al. (2014)	UK	(Following tax holiday) increase in the volume of transactions in the short-run
	Best and Kleven (2017)	UK	(Eliminating transaction tax) increase housing market activity in the short-run
	Floetotto et al. (2016)	US	Raising house prices and transaction volumes, and negative effect on welfare
Mortgage interest tax deduction	Gervais (2002)	US	(Repealing) Decline in homeownership and improvement in welfare gains
	Sommer and Sullivan (2018)	US	(Repealing) Decline in house price, increase in homeownership, decreases in mortgage debt, and improvement of welfare

Table 6 Dynamic impacts of housing tax and supply policies on housing prices, demand, and welfare of Seoul residents (unit: %)

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11–Y15	Y16–Y20	Mean
(a) Housing Price													
T_CO	− 1.57	− 1.65	− 1.74	− 1.82	− 1.90	− 1.98	− 2.06	− 2.14	− 2.21	− 2.29	− 2.49	− 2.80	− 2.29
T_IN	− 0.15	− 0.30	− 0.46	− 0.63	− 0.80	− 0.98	− 1.17	− 1.36	− 1.55	− 1.75	− 2.38	− 3.46	− 1.92
S_SS	0.15	− 0.33	− 0.81	− 1.30	− 1.79	− 2.27	− 2.76	− 3.25	− 3.74	− 4.22	− 5.66	− 7.99	− 4.43
S_SM	0.15	− 0.33	− 0.81	− 1.30	− 1.79	− 2.27	− 2.23	− 2.18	− 3.77	− 3.71	− 5.50	− 8.05	− 4.30
S_SL	0.15	− 0.33	− 0.81	− 1.30	− 1.79	− 2.27	− 2.23	− 2.18	− 2.12	− 2.07	− 5.25	− 8.14	− 4.10
S_MS	0.67	0.70	− 0.84	− 0.80	− 0.76	− 2.32	− 2.81	− 3.30	− 3.78	− 4.27	− 5.70	− 8.03	− 4.31
S_MM	0.67	0.70	− 0.84	− 0.80	− 0.76	− 2.32	− 2.28	− 2.23	− 3.81	− 3.75	− 5.54	− 8.09	− 4.18
S_ML	0.67	0.70	− 0.84	− 0.80	− 0.76	− 2.32	− 2.28	−2.23	− 2.17	− 2.12	− 5.30	− 8.18	− 3.98
S_LS	0.67	0.70	0.74	0.79	0.83	− 2.40	− 2.89	− 3.37	− 3.86	− 4.34	− 5.78	− 8.10	− 4.12
S_LM	0.67	0.70	0.74	0.79	0.83	− 2.40	− 2.35	− 2.30	− 3.89	− 3.83	− 5.61	− 8.15	− 3.99
S_LL	0.67	0.70	0.74	0.79	0.83	− 2.40	− 2.35	− 2.30	− 2.25	− 2.19	− 5.37	− 8.25	− 3.79
T_CO+S_LL	− 0.90	− 0.94	− 0.99	− 1.03	− 1.07	− 4.37	− 4.40	− 4.43	− 4.44	− 4.46	− 7.80	− 10.91	− 6.03
T_IN+S_LL	0.52	0.40	0.28	0.16	0.03	− 3.38	− 3.52	− 3.65	− 3.79	− 3.92	− 7.68	− 11.53	− 5.65
(b) Housing Demand													
T_CO	− 1.76	− 1.77	− 1.78	− 1.78	− 1.79	− 1.80	− 1.81	− 1.81	− 1.82	− 1.83	− 1.85	− 1.89	− 1.83
T_IN	− 0.17	− 0.33	− 0.50	− 0.66	− 0.83	− 1.00	− 1.16	− 1.33	− 1.50	− 1.67	− 2.18	− 3.03	− 1.76
S_SS	0.02	0.11	0.20	0.29	0.39	0.49	0.59	0.69	0.79	0.90	1.22	1.80	0.98
S_SM	0.02	0.11	0.20	0.29	0.39	0.49	0.49	0.49	0.80	0.80	1.19	1.82	0.95
S_SL	0.02	0.11	0.20	0.29	0.39	0.49	0.49	0.49	0.48	0.48	1.15	1.84	0.92
S_MS	− 0.07	− 0.07	0.20	0.21	0.21	0.50	0.60	0.70	0.80	0.90	1.23	1.81	0.96
S_MM	− 0.07	− 0.07	0.20	0.21	0.21	0.50	0.50	0.50	0.81	0.80	1.20	1.82	0.93
S_ML	− 0.07	− 0.07	0.20	0.21	0.21	0.50	0.50	0.50	0.49	0.49	1.15	1.85	0.90
S_LS	− 0.07	− 0.07	− 0.07	− 0.07	− 0.07	0.51	0.61	0.71	0.81	0.92	1.25	1.83	0.93

Table 6 (continued)

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11–Y15	Y16–Y20	Mean
S_LM	– 0.07	– 0.07	– 0.07	– 0.07	– 0.07	0.51	0.51	0.51	0.82	0.82	1.21	1.84	0.90
S_LL	– 0.07	– 0.07	– 0.07	– 0.07	– 0.07	0.51	0.51	0.51	0.51	0.50	1.17	1.86	0.87
T_CO+S_LL	– 1.83	– 1.83	– 1.84	– 1.85	– 1.86	– 1.30	– 1.31	– 1.32	– 1.33	– 1.34	–0.72	– 0.10	– 1.00
T_IN+S_LL	– 0.24	– 0.40	– 0.56	– 0.73	– 0.90	– 0.49	– 0.66	– 0.83	– 1.01	– 1.18	– 1.06	– 1.29	– 0.94
(c) Welfare (CV)													
T_CO	– 0.84	– 0.86	– 0.89	– 0.92	– 0.94	– 0.97	– 0.99	– 1.02	– 1.05	– 1.07	– 1.16	– 1.33	– 1.10
T_IN	– 0.07	– 0.15	– 0.23	– 0.32	– 0.42	– 0.53	– 0.64	– 0.77	– 0.90	– 1.04	– 1.52	– 2.53	– 1.27
S_SS	– 0.07	0.08	0.25	0.43	0.61	0.81	1.02	1.24	1.47	1.70	2.47	3.90	1.97
S_SM	– 0.07	0.08	0.25	0.43	0.61	0.81	0.80	0.78	1.48	1.47	2.40	3.93	1.91
S_SL	– 0.07	0.08	0.25	0.43	0.61	0.81	0.80	0.78	0.76	0.73	2.29	3.98	1.83
S_MS	– 0.25	– 0.30	0.26	0.23	0.20	0.83	1.04	1.26	1.49	1.73	2.50	3.92	1.93
S_MM	– 0.25	– 0.30	0.26	0.23	0.20	0.83	0.82	0.80	1.50	1.49	2.42	3.95	1.87
S_ML	– 0.25	– 0.30	0.26	0.23	0.20	0.83	0.82	0.80	0.78	0.75	2.31	4.00	1.79
S_LS	– 0.25	– 0.30	– 0.34	– 0.38	– 0.43	0.87	1.08	1.30	1.52	1.76	2.53	3.96	1.86
S_LM	– 0.25	– 0.30	– 0.34	– 0.38	– 0.43	0.87	0.85	0.83	1.54	1.53	2.46	3.99	1.81
S_LL	– 0.25	– 0.30	– 0.34	– 0.38	– 0.43	0.87	0.85	0.83	0.81	0.79	2.35	4.04	1.72
T_CO+S_LL	– 1.09	– 1.16	– 1.23	– 1.30	– 1.37	– 0.12	– 0.17	– 0.21	– 0.26	– 0.32	1.09	2.49	0.53
T_IN+S_LL	– 0.32	– 0.44	– 0.57	– 0.71	– 0.85	0.33	0.19	0.05	– 0.11	– 0.28	0.71	1.17	0.33

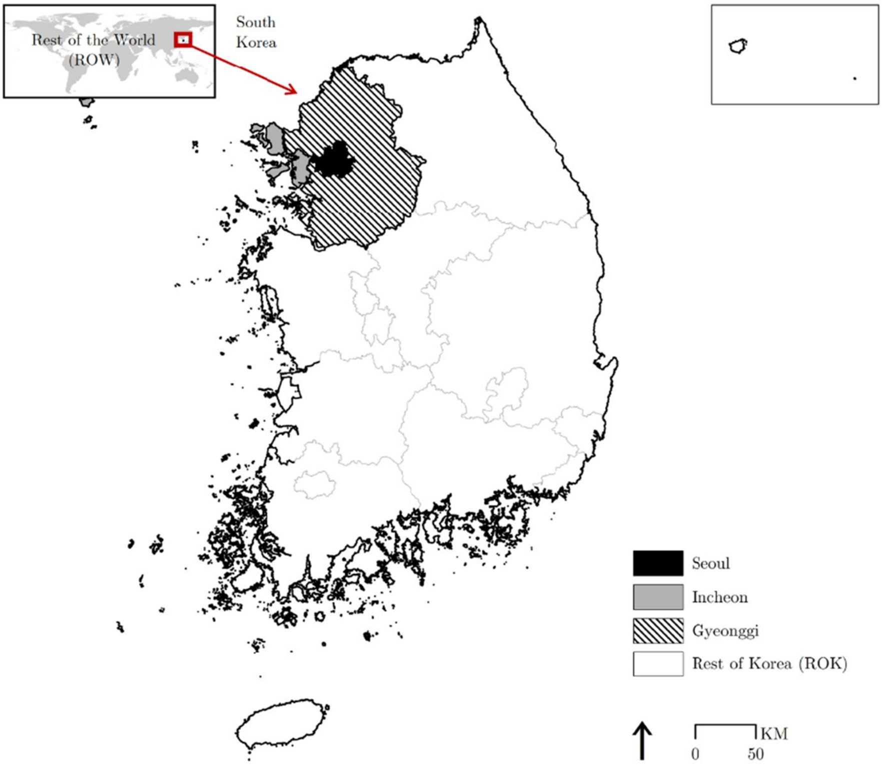

Fig. 7 Regions in H-CGE

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Agarwal S, Li K, Qin Y, Wu J, Yan J (2020) Tax evasion, capital gains taxes, and the housing market. J Public Econ 188:104222. https://doi.org/10.1016/j.jpubeco.2020.104222

Andrews D, Caldera Sánchez A, Johansson Å (2011) Housing markets and structural policies in OECD countries. OECD Economics Department, Working Papers, 836, 85. https://doi.org/10.1787/5kgk8t2k9vf3-en

Bai C, Li Q, Ouyang M (2014) Property taxes and home prices: a tale of two cities. J Econom 180(1):1–15. https://doi.org/10.1016/j.jeconom.2013.08.039

Babiker M, Gurgel A, Paltsev S, Reilly J (2009) Forward-looking versus recursive-dynamic modeling in climate policy analysis: a comparison. Econ Model 26(6):1341–1354

Benjamin JD, Coulson NE, Yang SX (1993) Real estate transfer taxes and property values: the Philadelphia story. J Real Estate Finance Econ 7(2):151–157. https://doi.org/10.1007/BF01258324

Bérard G, Trannoy A (2017) The impact of a rise in the real estate transfer taxes on the French housing market. Working Paper. Retrieved from https://halshs.archives-ouvertes.fr/halshs-01582528

Berkovec J, Fullerton D (1992) A general equilibrium model of housing, taxes, and portfolio choice. J Polit Econ 100(2):390–429

Besley T, Meads N, Surico P (2014) The incidence of transaction taxes: evidence from a stamp duty holiday. J Public Econ 119:61–70. https://doi.org/10.1016/j.jpubeco.2014.07.005

Best MC, Kleven HJ (2017) Housing market responses to transaction taxes: evidence from notches and stimulus in the UK. Rev Econ Stud. https://doi.org/10.1093/restud/rdx032

Brueckner JK (2011) Lectures on urban economics. MIT Press, Cambridge

Bye B, Åvitsland T (2003) The welfare effects of housing taxation in a distorted economy: a general equilibrium analysis. Econ Model 20(5):895–921

Cao J, Hu W (2016) A microsimulation of property tax policy in China. J Hous Econ 33:128–142. https://doi.org/10.1016/j.jhe.2016.05.004

Chambers M, Garriga C, Schlagenhauf DE (2009) Housing policy and the progressivity of income taxation. J Monet Econ 56(8):1116–1134. https://doi.org/10.1016/j.jmoneco.2009.10.007

Coleman A (2010) The long-term effects of capital gains taxes in New Zealand. N Z Econ Pap 44(2):159–177. https://doi.org/10.1080/00779954.2010.492575

Dachis B, Duranton G, Turner MA (2011) The effects of land transfer taxes on real estate markets: evidence from a natural experiment in Toronto. J Econ Geogr 12:327–354. https://doi.org/10.1093/jeg/lbr007

Davidoff I, Leigh A (2013) How do stamp duties affect the housing market? Econ Rec 89(286):396–410. https://doi.org/10.1111/1475-4932.12056

Devarajan S, Robinson S (2013) Contribution of computable general equilibrium modeling to policy formulation in developing countries. In: Dixon PB, Jorgenson DW (eds) Handbook of computable general equilibrium modeling. North-Holland, Oxford

Du Z, Zhang L (2015) Home-purchase restriction, property tax and housing price in China: a counterfactual analysis. J Econom 188(2):558–568. https://doi.org/10.1016/j.jeconom.2015.03.018

Eggleston J, Hays D, Munk R, Sullivan B (2020) The wealth of households: 2017 (Current Population Reports, P70BR-170). US Census Bureau. Retrieved from https://www.census.gov/content/dam/Census/library/publications/2020/demo/p70br-170.pdf

Feather C (2019) The two million housing drive in Korea: a supply solution for affordable housing in the developing world. Int J Hous Mark Anal 12(5):906–933. https://doi.org/10.1108/IJHMA-01-2019-0004

Feltenstein A, Rider M, Sjoquist DL, Winters JV (2017) Reducing property taxes on homeowners an analysis using computable general equilibrium and microsimulation models. Public Finance Rev 45(4):484–510

Floetotto M, Kirker M, Stroebel J (2016) Government intervention in the housing market: Who wins, who loses? J Monet Econ 80:106–123. https://doi.org/10.1016/j.jmoneco.2016.04.005

Fritzsche C, Vandrei L (2019) The German real estate transfer tax: evidence for single-family home transactions. Reg Sci Urban Econ 74:131–143. https://doi.org/10.1016/j.regsciurbeco.2018.08.005

Fu Y, Qian W, Yeung B (2016) Speculative investors and transactions tax: evidence from the housing market. Manag Sci 62(11):3254–3270. https://doi.org/10.1287/mnsc.2015.2268

Funke M, Kirkby R, Mihaylovski P (2018) House prices and macroprudential policy in an estimated DSGE model of New Zealand. J Macroecon 56:152–171

Ge X, Li XL, Zheng L (2020) The transmission of financial shocks in an estimated DSGE model with housing and banking. Econ Model 89:215–231
Gervais M (2002) Housing taxation and capital accumulation. J Monet Econ 49(7):1461–1489. https://doi.org/10.1016/S0304-3932(02)00172-1
Glaeser EL, Gyourko J (2003) The impact of building restrictions and housing availability. Econ Policy Rev 9:21–39
Glaeser E, Gyourko J (2018) The economic implications of housing supply. J Econ Perspect 32(1):3–29. https://doi.org/10.1257/jep.32.1.3
Glaeser EL, Gyourko J, Saiz A (2008) Housing supply and housing bubbles. J Urban Econ 64(2):198–217. https://doi.org/10.1016/j.jue.2008.07.007
Glaeser EL, Gottlieb JD, Tobio K (2012) Housing booms and city centers. Am Econ Rev 102(3):127–133. https://doi.org/10.1257/aer.102.3.127
Guerrieri V, Hartley D, Hurst E (2013) Endogenous gentrification and housing price dynamics. J Public Econ 100:45–60. https://doi.org/10.1016/j.jpubeco.2013.02.001
Gyourko J (2009) Housing supply. Annu Rev Econ 1:295–318. https://doi.org/10.1201/9781315639086-7
Gyourko J, Molloy R (2015) Regulation and housing supply. Handb Region Urban Econ 5:1289–1337. https://doi.org/10.1016/B978-0-444-59531-7.00019-3
Gyourko BJ, Mayer C, Sinai T (2013) Superstar cities. Am Econ J Econ Pol 5(4):167–199
He Y, Xia F (2020) Heterogeneous traders, house prices and healthy urban housing market: a DSGE model based on behavioral economics. Habitat Int 96:102085
Hilber CA, Lyytikainen T (2012) Stamp duty and household mobility: regression discontinuity evidence from the UK. Spatial Economics Research Centre. Discussion papers
Holt CC, Shelton JP (1962) The lock-in effect of the capital gains tax rate. Natl Tax J 15:337–352
Iacoviello M (2010) Housing in DSGE models: findings and new directions. Housing markets in Europe: a macroeconomic perspective, 3–16
Iacoviello M, Neri S (2010) Housing market spillovers: evidence from an estimated DSGE model. Am Econ J Macroecon 2(2):125–164
Jeon J (2019) How housing market responds to green-belt realization: case of Seoul Metropolitan Area, South Korea. Land Use Policy 84:328–334
Jeong J (2008) Analysis of tariff structure on the economy, Korea Institute of Public Finance (**in Korea**)
KB Kookmin Bank (2023) KB Property Data Hub. Available at: KB Property Data Hub. https://data.kbland.kr/ (accessed December 13, 2023)
Keast SJ (2010) A bi-regional CGE model of the south west housing market. Unpublished Ph.D. Dissertation, Plymouth University
Kim A (2008) Impact of housing tax policies on housing demand and income distribution using CGE model. Unpublished Master Thesis, Seoul National University
Kim E, Ju J (2003) Economic analysis of urban land use and housing supply: an application of urban land use and a CGE Model for Seoul. Comput Gener Equilib Approach Urban Region Policy Stud 15(1):167–186
Kim K, Park M (2016) Housing policy in the Republic of Korea. Asian Development Bank Institute. ADBI Working Paper Series Housing, No. 570
Kim E, Kim A, Moon I (2022) Government intervention in real estate market: is tax reform effective in seoul housing market? In: Kawano M, Kourtit K, Nijkamp P, Higano Y (eds) Theory and history in regional perspective. New frontiers in regional science: Asian perspectives, vol 56. Springer, Singapore, pp 221–243
Knight Frank (2021) Global Residential cities index. Retrieved from https://content.knightfrank.com/research/1026/documents/en/global-residential-cities-index-q1-2021-8210.pdf
Korea Real Estate Board (2002) Multi-family house actual transaction price index. Retrieved from https://www.reb.or.kr/r-one/statistics/statisticsViewer.do?menuId=TSPIA_41100 (**in Korean**)
Lee J, Song J (2015) Housing and business cycles in Korea: a multi-sector Bayesian DSGE approach. Econ Model 45:99–108
Lee S, Chung E (2010) An analysis of impact of debt-to-income regulation on housing tenure decisions of urban households. Seoul Stud 11(1):83–101 (**in Korean**)
Liberati D, Loberto M (2019) Taxation and housing markets with search frictions. J Hous Econ 46(March):101632. https://doi.org/10.1016/j.jhe.2019.05.001
Mankiw NG, David NW (1989) The baby boom, the baby bust, and the housing market. Reg Sci Urban Econ 19(2):235–258

Mora-Sanguinetti JS, Rubio M (2014) Recent reforms in spanish housing markets: an evaluation using a DSGE model. Econ Model 44:S42–S49

Ng EC (2015) Housing market dynamics in China: findings from an estimated DSGE model. J Hous Econ 29:26–40

Nordvik V (2006) Selective housing policy in local housing markets and the supply of housing. J Hous Econ 15:279–292

Park J, Lee T, Bae Y, Jeong H, Choi S (2014) An analysis on economic impacts of changes in property tax. Korea Research Institute for Human Settlements, 2014–29 (**in Korean**)

Peng S, Wang P (2009) A normative analysis of housing-related tax policy in a general equilibrium model of housing quality. J Public Econ Theory 11(5):667–696

Petkova K, Weichenrieder AJ (2017) Price and quantity effects of the German real estate transfer tax. Working paper, Center for Economic Studies and ifo Institute. No. 6538. Retrieved from https://www.econstor.eu/bitstream/10419/167524/1/cesifo1_wp6538.pdf

Poterba JM (1992) Taxation and housing: old questions, new answers. Am Econ Rev 82(2):237–242. https://doi.org/10.2307/2117407

Rosenberg S (2019) The effects of conventional and unconventional monetary policy on house prices in the Scandinavian countries. J Hous Econ 46:1051–1377

Rubaszek M, Rubio M (2020) Does the rental housing market stabilize the economy? A micro and macro perspective. Empir Econ 59(1):233–257

Ryu K, Kim J (2018) Jeonse, will it be extinguished? Differentiation of Korean rental housing market. J Hous Built Environ 33:409–427. https://doi.org/10.1007/s10901-017-9571-4

Sommer K, Sullivan P (2018) Implications of US tax policy for house prices, rents, and homeownership. Am Econ Rev 108(2):241–274. https://doi.org/10.1257/aer.20141751

Statistics Korea (Multiple: 2010.2019) Korea Housing Survey

Statistics Korea (2022) Korean Statistical Information Service (KOSIS) Database. Available at: https://kosis.kr/search/search.do (accessed April 15, 2022)

Statistics Korea, and Bank of Korea (2021) Korean National Balance Sheets for 2020. Retrieved from http://kostat.go.kr/portal/eng/pressReleases/10/5/index.board?bmode=read&bSeq=&aSeq=390924&pageNo=1&rowNum=10&navCount=10&currPg=&searchInfo=&sTarget=title&sTxt=

Shin HS, Yi HC (2019) The Korean housing market: its characteristics and policy responses. In: Nijskens R, Lohuis M, Hilbers P, Heeringa W (eds) Hot property. Springer, Cham. https://doi.org/10.1007/978-3-030-11674-3_16

Stroebel J, Floetotto M, Kirker M, Stroebel J (2016) Government intervention in the housing market: Who wins, who loses? J Monet Econ 80:106–123. https://doi.org/10.1016/j.jmoneco.2016.04.005

Tan Z, Tang Q, Meng J (2022) The effect of monetary policy on China's housing prices before and after 2017: a dynamic analysis in DSGE model. Land Use Policy 113:105927

Van Ommeren J, Van Leuvensteijn M (2005) New evidence of the effect of transaction costs on residential mobility. J Reg Sci 45(4):681–702