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ABSTRACT
This paper explores whether the population size of the Seoul Metropolitan Area (SMA) in Korea is efficient in terms of the national economy. To undertake this analysis, we develop a recursively dynamic Interregional Computable General Equilibrium (ICGE) model with a population module. In our model, the explicit costs and benefits of population growth are estimated by using the industrial value added and consumer price inflation functions for each region. Our counterfactual analysis shows that national population decentralization away from the SMA is desirable for Korea's economic growth. Korea's GDP is estimated to be maximized when the SMA's national population share is at 39% in the short term and 35% in the long term. However, the SMA government is likely to have incentive to maintain its population at around 40% of the national population, where per capita income at the regional, not national, level is maximized.

KEY WORDS: Optimal Size; Urban Population; CGE model; Agglomeration; Seoul

1. Background

For the last several decades, Korea has experienced an increasing imbalance between the Seoul Metropolitan Area (SMA) and the rest of Korea (ROK), in terms of population and socioeconomic opportunities. The 2010 census and national account statistics (NSO, 2012) show that the SMA, occupying 12% of the national total land area, accounts for 49% of Korea's population and 48% of Korea's Gross Domestic Products (GDP). Also located in the SMA are the vast majority, more than three quarters, of Korea's largest enterprises and central government departments and agencies (Park and Kim, 2002). Such SMA-centered socioeconomic geography has been a source of serious conflicts between the SMA and the ROK. Many ROK entities have claimed that the overwhelming economic dominance of the SMA is due to government favoritism toward Seoul—Korea's current capital city—rather than to market forces such as economies of scale.[1] Accordingly, they have asked for the central government's strong interventions to reverse the persistent divergence dynamics.

So far, the Korean government has responded to such requests through various measures distorting market-based resource allocations between the SMA and the ROK (Lee, 2007). One of the measures is growth control over the SMA. The SMA is at present subject to the strict land use regulations that discourage a further attraction of population-inducing facilities within the region, such as manufacturing plants and universities (Kim et al., 2004). A decision to relocate central government departments and agencies to a new administrative capital, away from Seoul in 2005 (150 km from Seoul), is another example of the public responses to the growing regional disparity.

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[1] This claim may not be entirely true, but has some empirical base. In 2010, for example, the SMA's national GDP share (48%) was slightly lower than its national population share (49%), meaning the region's per capita GDP level is lower than the ROK's. This suggests little evidence of efficiency gains from agglomerations, which may justify Korea's SMA-centered socioeconomic geography.

The effectiveness of such control measures has been in question, however, given another stream of public policies that aim to strengthen the SMA's global competitiveness. While constraining the growth of the SMA, the Korean government has at the same time paid attention to restructuring the SMA toward a more knowledge-intensive economy, specialized in the high technology industries and able to provide various specialized producer services. This is to help the SMA compete with other nearby global city-regions—such as Shanghai, Tokyo, and Hong Kong—to attract foreign investment, and has led to huge capital investment in the region (Kim, 2011). Accordingly, supportive policy measures for the project have functioned as powerful population-pulling factors, offsetting the effect of the SMA's growth control. The simultaneous pursuit of the regional policies with conflicting goals suggests the presence of competing ideas between national and regional economic viewpoints about an "optimal" size of the SMA.

This situation raises several questions. In the first place, what would be an optimal size of the SMA? As claimed by the localities of the ROK, can Korea's national economy benefit from a reduced size of the SMA? Or as suggested by Korea's SMA restructuring project, should the SMA grow further for its increased global competency, which would eventually benefit the national economy, as well? Also, can Korea's current regional policy, aiming at the control of the SMA's further growth, be justified from an economic perspective? These are crucial questions to be examined before implementing relevant regional policy, but Korea's regional policy has been formulated without having clear answers for them. This study is motivated to provide empirical evidence on these questions. We understand the economic rationale of the public interventions that control the SMA's growth, only if there is evidence that the SMA is currently subject to diseconomies of agglomeration.

To answer these questions, we develop a method to estimate efficient city sizes, based on an

economy-wide computable general equilibrium (CGE) framework, and then apply this method to test whether the current level of SMA primacy in Korea's urban hierarchy deviates substantially from its estimated "ideal" size. Our analysis involves expanding the interregional CGE model developed in Kim et al. (2011) to compute a population range where a unit population increase contributes positively to national economic growth. Following the existing urban studies literature, we define an "efficient" size of a city as a population range where the city's aggregate net benefit is positive and an "optimal" size as the population level where the city's aggregate net benefit is maximized. We use GDP as a measure of aggregate net benefit, and focus on the SMA's population level maximizing its share of Korea's GDP or Korea's GDP itself. More details on our methodology are provided in Section 3.

We structure this paper as follows. First, we review the existing literature on optimal city sizes and their distribution, and consider the implications for this study. In Section 3, we develop our method, which combines a stylized interregional CGE model with a population module. Section 4 synthesizes our simulation results and findings, and Section 5 further discusses the results in connection with Korea's regional policy. Finally, Section 6 offers our conclusions.

2. Literature Review

Researchers have taken two approaches to estimating city sizes (Nam and Reilly, 2012). One approach, inspired by Zipf's finding of quasi-natural regularity existing in urban hierarchies, considers urbanization to be a process that is largely predetermined beyond economic dynamics. Although Zipf (1949) himself does not provide any theoretical framework underlying rank-size regularities, more recent studies have shown that Zipf's law can be invoked when the random or proportionate urban growth hypothesis holds (Gabaix, 1999; Eeckhout, 2004). Despite the lack

of theoretical background, Zipf's law has attracted substantial attention in the urban studies field, as the rank-size regularity based on it has been found to be robust in many countries (Guérin-Pace, 1995; Petrakos et al., 2000; Song and Zhang, 2002; Ioannides and Overman, 2003; Soo, 2007). Following in Zipf's footsteps, contemporary scholars have introduced various functional forms beyond the Pareto distribution function—such as log-normal and q-exponential functions—to better explain the regularities involved in urban hierarchies (Malacarne et al., 2001; Gabaix and Ioannides, 2004; González-Val, 2010).

The other approach views a city's size as an outcome of interactions among various economic actors and variables. This approach is more relevant to our research purpose, as it looks at the size of a given city as a certain optimization outcome rather than as a random process determined by the preexisting urban hierarchy. A key assumption underlying this approach is that there exists a certain ideal size for a city to attain high economic efficiency (Fujita et al., 1999). Early studies taking this approach aimed to find *the* optimal city size with little consideration of various socio-economic conditions that each particular city may confront (Leven, 1968). However, more recent works are based on the notion that there can exist multiple optimal sizes for cities (Arnott, 1979). The rationale for multiple optima is that the extent of external economies that each city can enjoy is likely to vary depending on its economic base—although many cities may share a similar form of disutility function with regard to their scale—because (i) each city is specialized in a small but distinct set of industrial sectors; and (ii) the extent of external economies of scale substantially differs across sectors (Henderson, 1974). The second approach, however, has involved controversies regarding the very definition of optimality. Much of the early literature defines optimality in city size in terms of net costs of public services with regard to urban population size (Richardson, 1972), but recent works tend to employ the

efficiency concept to define this optimality (Henderson, 1988). Accordingly, the optimal size of a city is often defined as a population level where external economies of scale are maximized or the marginal social utility of a unit population increase is close to zero. However, no consensus has yet been reached about from whose perspective city sizes should be optimized. More recent work, reflected in Bettencourt and West (2011), suggested that doubling the population size of a city resulted in average increase of around 15 percent in measures such as wages and patents produced per capita. Further they claimed that a city of say 8 million needed 15% less infrastructure than two cities of four million each.

One group of studies solves the optimization problem only for cities in order to draw an optimal size of a given city or to assess deviation of a city's actual size from its "ideal" size. Although these studies all look at optimality in city size as a problem to be solved from a city's perspective, they take different approaches to testing optimality. Largely, their framework either involves estimation of net marginal benefit functions defined on a particular city size and its unit increase (Yezer and Goldfarb, 1978; Capello and Camagni, 2000; Zheng, 2007) or employs the Henry George Theorem for an optimality-testing purpose (Kanemoto *et al.,* 1996). Empirical analyses suggest that the various socio-economic conditions each country faces may propose a different optimal city size by country. For example, Yezer and Goldfarb (1978) estimated that a city size of 2.5 million people or above would maximize net agglomeration economies in the United States, while Capello and Camagni (2000) arrived at slightly over half a million as a comparable number for Italy. Empirical results also show that different approaches may lead to different conclusions even for the same country. For example, Kanemoto *et al.* (1996), assuming that the Henry George Theorem holds in reality and then comparing land value and Pigouvian subsidy to test optimality, concluded that the Tokyo Metropolitan Area is not overpopulated.

Zheng (2007), optimizing a surplus function estimated for major Japanese cities, argued that Tokyo's actual population of 32 million substantially deviates from 18 million, the population at which net agglomeration economies are maximized for that region.

There are also studies that view optimality in city size as a problem to be solved from a broader (i.e. national or regional) perspective. This optimization scheme often uses the primacy of the largest city as a key metric, whose optimal level may vary across countries, depending on their scale in terms of land area, economic development stage, and socio-political institutions (Henderson, 2003). Estimates of efficient city size from this optimization perspective may be especially relevant for national policymakers or planners. This is because the optimal size of a particular city is likely to be a function of its position in the national urban hierarchy, and increasing spatial income disparities are often one of the most serious issues in the developing world that need immediate public intervention (Suh, 1991; Venables, 2005). It is not unusual for a national government to ask urban economies to sacrifice their growth potential to achieve a certain national policy goal. China presents a good example. According to Au and Henderson (2006), postulating an inverted U-shape of real income per worker against city employment, approximately two-thirds of the 205 Chinese major cities analyzed appear to be too small (thus suboptimal in size) to fully capture their own agglomeration economies—mainly because the Chinese central government has placed strict restrictions on domestic migration.

In sum, the following two implications for this study can be drawn from the literature. First, issues related to ideal city size can be viewed as an optimization problem, and this optimization approach, rather than Zipf's, fits our research purpose. Secondly, existing studies based on the optimization approach tend to look at optimality in city size either as an outcome of a city-level optimization problem or of a national level equilibrium analysis, although both city and national

level perspectives should be considered when formulating a national spatial policy. Comparison of optimality in city size from a city's perspective and from a national perspective is a primary goal of our study. Dealing with the mismatch between the compared estimates will be further discussed in Section 4.

3. Method

Our methodology incorporates regional population in industrial productivities and cost inflation of regions in a unique fashion with stylized CGE models. The basic structure of this model is based on Kim et al. (2011), but specific equations are modified or added to account for marginal net-benefit of population for each region and sector. Consequently, the interregional computable general equilibrium (ICGE) model is designed to assess the economic impacts of population on national growth and the distribution of growth between two subnational regions in Korea. The objective here is to consider optimal or efficient urban size in an economy-wide perspective rather than to focus exclusively on the benefits accruing to the city alone.

3.1. Brief Description of the ICGE Model

The ICGE model is recursive, as it employs a set of equations that expand the SAM data for previous time points for the subsequent time periods; it is also dynamic because it is capable of running simulations for a total of 10 time periods. We reconstruct the original SAM so that the ICGE model has three regions—the SMA, the ROK, and the rest of the world (ROW)—and four sectors—agriculture, manufacturing, construction and services. The modified SAM consists of six accounts—factors, households, production sectors, government, capital, and the ROW—and the ICGE comprises six economic agents—two regional households, two regional governments,

one national (central) government, and the ROW. For a more detailed description of the ICGE

model other than that provided below, see Kim et al. (2011).

We adopt a conventional CGE framework to model economic agents' behavior. In the ICGE,

each agent optimizes its utility or profit levels under the set of constraints it faces; thus, an

economy-wide general equilibrium is attained under market clearance, zero profit, and zero

income conditions. Ultimately, the ICGE aims to estimate explicit marginal net-benefit with

regard to population by using the industrial value-added and inflation functions for each region.

For this purpose, we construct a system of equations in the ICGE (Table 1) in such a way that an

efficient size of a region is computed in terms of population levels, where (i) a marginal

contribution of population to the national economy, as well as to a particular sub-national

economy, is close to zero but still positive, (ii) GDP at the national level is maximized, and (iii)

the aggregate net benefit of agglomeration is maximized.

Table 1: Major Equations in ICGE Model

Output	Output = Leontief (Value added, Intermediate demand)
Value added	Value added = Total Factor Productivity*CD (Capital stock,)
Total factor productivity	Total factor productivity = TFP(Population, Population^2)
Supply	Output = CET (Foreign exports, Domestic supply)
Domestic supply	Domestic supply = CET (Regional exports, Intraregional supply)
Demand	Demand = Armington (Foreign imports, Domestic demand)
Domestic demand	Domestic demand = Armington (Regional imports, Intraregional supply)
Labor demand	Labor demand = LD (Wage, Value added, Net price)
Wage	Wage = WA (Lagged wage rate, Inflation rate)
Labor supply	Labor supply = LS (Labor market participation rate, Population)
Population	Population = Natural growth of previous year's population + Net population inflows
Regional incomes	Regional incomes = Wage + Capital returns + Government subsidies
Migration	Migration = TODARO (Incomes and Employment opportunities of origin and destination, Distance between origin and destination)
Government revenues	Government revenues = Indirect tax + Direct tax + Tariff
Government expenditures	Government expenditures = Government current expenditure + Government savings + Government investment expenditure + Government subsidies
Consumer price index	Consumer price index = CPI(Foreign exchange rate, Land price, Excessive demand, Population)
Labor market equilibrium	Labor demand = Labor supply

Capital market equilibrium	Private savings = Total investments
Commodity market equilibrium	Supply of commodities = Demand of commodities
Government	Government expenditures = Government revenues
Capital stock	Capital stock = Depreciated lagged capital stock + New investments

The ICGE has two sub-systems: within-period and between-period modules. First, the within-period module determines equilibrium quantity and price levels, computed under objectives and constraints for each economic agent. The equilibrium from this module represents a market clearance level in a perfectly competitive market. This module incorporates a square system of equations with 204 equations and 239 variables, which ensures a unique solution given that the number of endogenous variables is identical to the number of equations under the convexity assumption. Some parameters, such as world market prices or government expenditures, are given exogenously, and the numeraire of the module is indexed to the consumer price index. We calibrate the ICGE model by using the existing SAM data as a benchmark equilibrium level.

Once the simulation of the within-period module is completed, we run the between-period module to find a sequential equilibrium path over the time periods of our analysis by using the within-period simulation results. In its optimization process, the between-period module endogenously determines and updates values of key exogenous variables, such as government expenditures, for the future time periods. For example, the amount of capital stock at time point t is determined by the sum of capital stock at time t-1 and the change in the capital stock between t and t-1 (the difference between the depreciated portion of the existing capital stock and new investment at time t). The between-period module takes 2005 as the base year and adjusts key parameters across time periods by replicating the equilibrium conditions for the base year.

We run the ICGE for 10 time periods to simulate 13 scenarios (12 counterfactual scenarios

and one baseline case), each of which endows the SMA with a different population size. With total national population size fixed, the model can estimate the marginal increase of the relative share of the SMA or the marginal decrease of the relative share of the ROK population on the national and regional income growth. It reveals the range of efficient population size for the SMA and its optimal size by scenario. By interpreting the simulation results, we can determine whether a decrease in the SMA's population is desirable in terms of achieving a higher level of efficiency at the national level.

3.2. ICGE's Equilibrium Dynamics

Our production structure model has three stages. In the first stage, the gross output by region and sector is determined via a two-level production function of value-added and composite intermediate inputs. That is, in accordance with the Leontief production function, the producer coordinates the level of intermediate demand and value-added elements against a fixed proportion of gross output. The intermediate inputs are derived from interregional input-output coefficients, whereas the total value-added is determined by the given Cobb-Douglas production function of labor input, capital stock, and the total factor productivity. We assume that the labor input is homogeneous across regions and mobile across sectors but capital stock is region-specific and immobile across regions. To account for the relation between marginal effects of the regional population on production (benefits) and costs, there are two types of equations; a total factor productivity (TFP) equation of manufacturing and service sectors to estimate the benefit side of the population concentration and consumer price index equation by region to address the cost side. The basic idea for the model specification is derived from Robinson (1973) as shown in Figure 1. The TFP or benefit curve is assumed to be S-shaped; the per

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capita benefit of region increases faster than the population growth at the first stage and at a diminishing rate at the second stage, but decreases in the final stage. The cost curve is also assumed to be U-shaped with minimum cost at very early stage. Conceptually, the cost could include costs of living, commuting costs, and costs of noise and congestion associated with the population size. In Figure 1, the population level P_2 is defined as an optimal size to maximize net benefits under the fixed total population size, and P_1 and P_3 are lower and upper ceilings of the efficient population size, respectively.
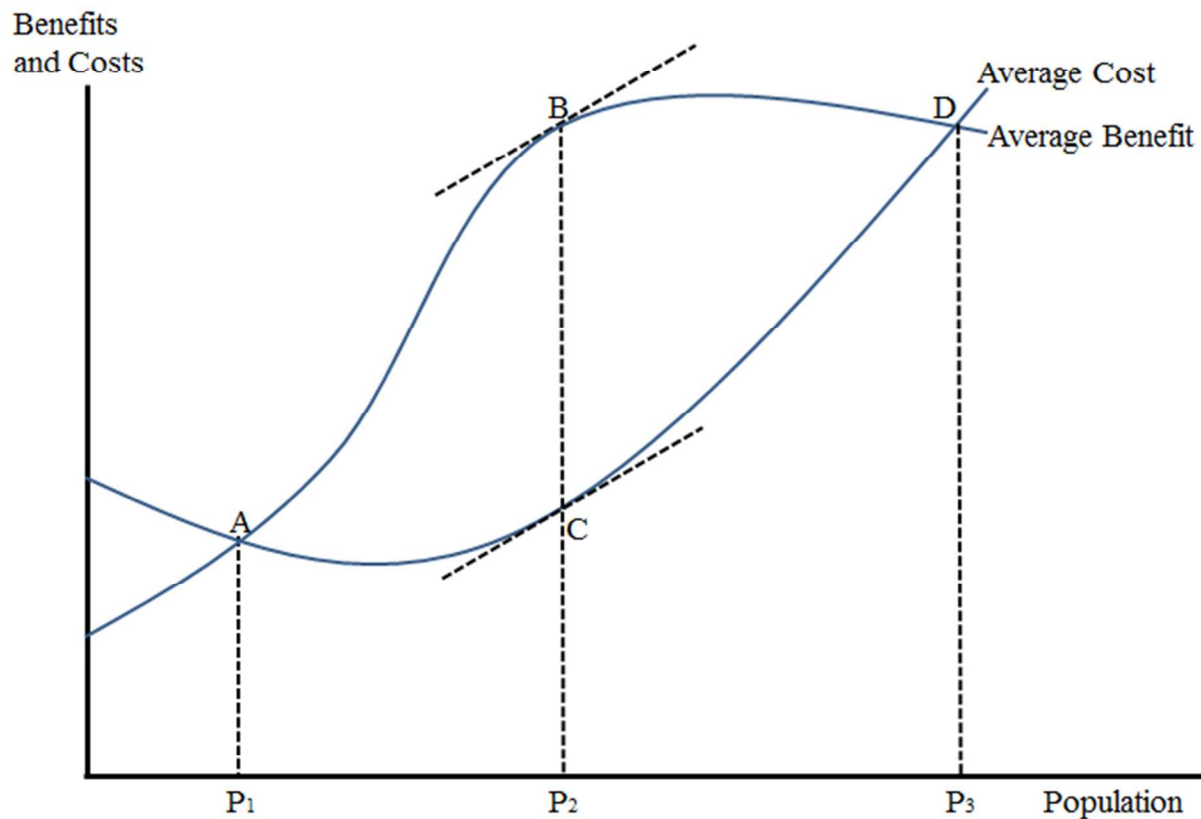

Figure 1: Average Benefit and Average Cost of Population
Source: Created from Richardson (1973).

The benefit function of the population concentration in terms of the production and TFP model, displayed as equation (1), estimates the marginal contributions of population to national or subnational economies, using value-added functions. In the equation, Y_t, L_t, K_t, and P_t are the output level (measured in value-added terms), labor input, capital stock, and regional population at time *t*, respectively, and Y_t is assumed to be a function of L_t, K_t, and P_t.   We use only the population variable, P_t as a proxy for urbanization economies and assume that it has a non-linear (in particular, inverted U-shaped) relationship with TFP_t, as suggested by the literature. Thus, we expect the signs of γ_1 and γ_2 in equation (1) to be positive and negative, respectively, while α_1 is calibrated with the benchmark date set. The cost function of the population, shown as equation (2), measures the marginal cost of population, using a price inflation function. In equation (2), CPI_t, $FOREX_t$, $LAND_t$, DS_t, and P_t are the consumer price index, foreign exchange rate, land price, regional demand-supply ratio, and regional population at time *t*. While many studies derive inflation rates by using sector-specific price levels determined endogenously by a CGE model, we take a different approach by estimating the rates from four cost factor variables ($FOREX_t$, $LAND_t$, DS_t, and P_t). Table 2 presents the main results of the estimation for the TFP and the cost inflation functions, and the overall results do not have any serious statistical problems.   All the variables have expected signs but the land price variable in the cost inflation equation of the ROK is statistically insignificant and the *p*-value of the population variable of the SMA is 0.1763.

$$\log Y_t = \log TFP_t + \alpha_1 \log L_t + (1 - \alpha_1)\log K_t \tag{1}$$

where $\log TFP_t = \gamma_0 + \gamma_1 P_t + \gamma_2 P_t^2$

$$LogCPI_t = \beta_0 + \beta_1 \log FOREX_t + \beta_2 \log LAND_t + \beta_3 \log P_t \qquad (2)$$

Table 2: Estimation Results of TFP and Inflation Functions of Regions

1) $\log TFP_t = \gamma_0 + \gamma_1 P_t + \gamma_2 P_t^2$

Variable	Manufacturing sector of SMA	Service sector of SMA	Manufacturing sector of ROK	Service sector of ROK
γ_1	0.8046 (20.88)	2.2124 (19.08)	0.1396 (22.60)	0.3184 (20.00)
γ_2	-0.0593 (-14.72)	-0.1667 (-13.77)	-0.0013 (-13.30)	-0.0031 (-12.11)
Adjusted R^2	0.9691	0.9601	0.9599	0.9461

The parameter value of the constant (γ_0) is set to zero in term of statistical significance.

2) $LogCPI_t = \beta_0 + \beta_1 \log FOREX_t + \beta_2 \log LAND_t + \beta_3 \log P_t$

Variable	SMA	ROK
β_0	-0.0977 (-2.04)	-0.0747 (-3.46)
β_1	0.3773 (4.92)	0.2911 (7.85)
β_2	0.5307 (4.81)	0.0080 (0.66)
β_3	0.0302 (1.39)	0.4981 (9.34)
Adjusted R^2	0.6442	0.6630

Labor demand by region and industry is derived from the first order condition of producers' profit maximization, whereas labor supply relies on the rates of participation in economic activities and the total size of the regional population. Under the neoclassical closure rule for labor market equilibrium, labor participation rates are determined at the point where total labor supply meets total labor demand. Changes in the size of labor pool available for each region are computed as the sum of the natural growth of native population and the social growth driven by cross-regional migration. The size of net-migration for each region, which is a function of cross-regional wage differentials and physical distance, is determined endogenously within the model.

In the second stage, intermediate demand is decomposed into demand for domestic products and demand for foreign imports. We assume Armington goods and thus imperfect substitutability

among commodities with different regional origins. Under the Armington assumption, cost minimization leads to an optimal ratio between foreign imports and domestic products. Foreign imports rely for demand on three determinants of domestic sales: the price of domestic products relative to foreign imports, a share parameter, and the level of elasticity of substitution.

In the final stage, demand for an intra-regional product is determined by its price and total demand under the Cobb-Douglas function. However, profit maximization according to the two-level constant elasticity of transformation (CET) function determines the optimal allocation of the gross output via two competing commodities: those intended for the domestic market and those for foreign markets. The former category includes both intraregional supplies and regional exports. The ratio of foreign exports to gross output depends on the price of domestic products relative to foreign exports, the share parameter, and the elasticity of transformation under revenue maximization.

The total demand for goods and services is the sum of intermediate demand, household consumption, investment, and government expenditure. Total household income consists of wage, capital income, and government subsidies. Total household consumption is a linear function of total household income, direct tax rates of regional and national governments, and the marginal propensity to save. After paying income taxes and allocating for savings, the household assigns total consumption expenditures to each commodity. Household savings are proportional to household disposable incomes, with a fixed marginal propensity to save.

Investment is determined by aggregate savings, with regard to the macroeconomic closure rule for the capital market. We assume one consolidated capital market, consisting of household savings, corporate savings of regional production sectors, private borrowing from abroad, and government savings. There are no financial assets in the model, so overall consistency requires a

total domestic investment level identical to the sum of net national savings and net capital inflows. The sectoral allocation of total investment by destination is endogenously determined by capital price for each sector and the allocation coefficient of investment. Sectoral investment by destination is transformed into sectoral investment by origin through a capital coefficient matrix. This price adjustment process is required to fulfill the Walrasian equilibrium condition, and every price is measured in a relative scale.

Two tiers of government structure are specified in the ICGE model: two regional governments and one national government. Government expenditures consist of consumption expenditures, subsidies to producers and households, and savings. Revenue sources include taxation of household incomes, value-added, and foreign imports. It is difficult to estimate the economic effects with confidence, due to the deterministic feature of the ICGE model, but model reliability and its robustness of the results could be examined by a sensitivity analysis with respect to key parameter values (De Maio et al., 1999). In this paper, the GDP could only be reduced by 0.01% and 0.16%, respectively, if the elasticities of the consumer price index by region and of transformation for CET functions increased by 1%. This shows that the model is comparatively stable for counterfactual analysis.

4. Policy Simulation Results

As previously mentioned, our analysis requires running the ICGE for 10 time periods under 13 scenarios. We construct the baseline scenario, representing a reference case under the existing policy framework, in such a way that the SMA's population share follows the predetermined path shown in Figure 2. The other 12 scenarios reflect counterfactual conditions that can be attained under different policy options from the existing ones, and each is set to have a different

population share for the SMA. After simulations are completed for all the scenarios, we compare

the simulation results of counterfactual scenarios with those of the baseline scenario. Each

scenario is expected to generate a dissimilar equilibrium because the ICGE determines total

factor productivity for a particular sector in each region, based in part on the SMA's share of the

national population given exogenously. However, the direction of population's marginal

contribution to productivity is uncertain due to the quadratic form of the aggregate benefit

function and the linear form of the aggregate cost function used in the ICGE.
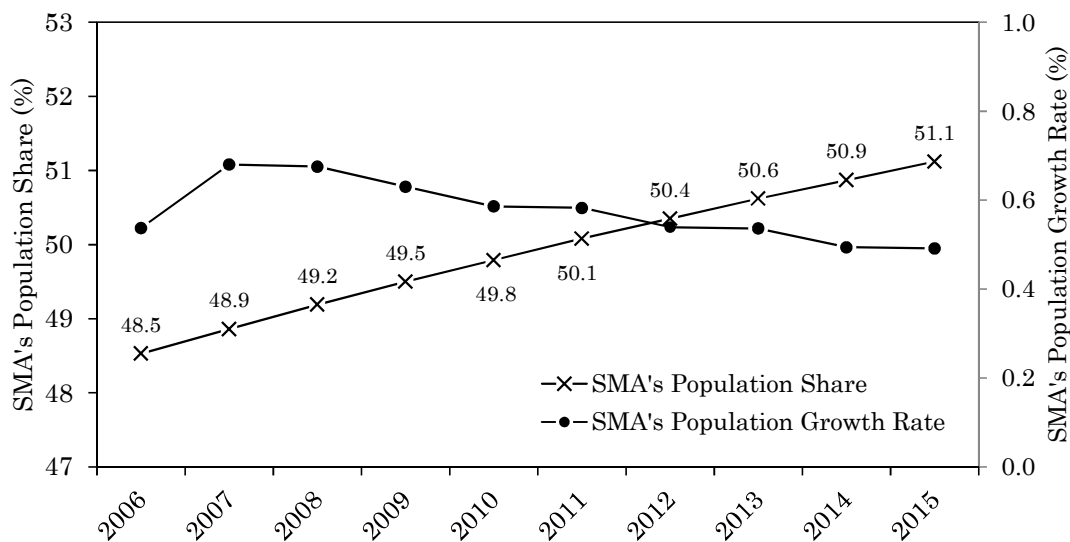
Figure 2: SMA's Population Share in Baseline Scenario, 2006-2015
Source: Created from NSO (2012).

Before analyzing the results, it is worthwhile to examine effects of changes in the regional

population on the incomes in terms of the model structure.   As discussed in the previous section,

the population has both positive and negative economic growth impacts.   Overall, it is expected

that exogenous population growth leads to higher per capita income (AB in Figure 1) until the

optimal level maximizing net benefits per capita (gap between AB and AC in Figure 1) in the

benefit channel of Figure 3.   This population change would result in positive impacts on the

productivities in the manufacturing and service sectors, while the negative effect such as living

cost inflation could be found in the cost channel.   It implies that a net change in the regional per

capita income at constant price depends on the gap between differentiated speeds or elasticity

values of population with respect to productivities and costs.
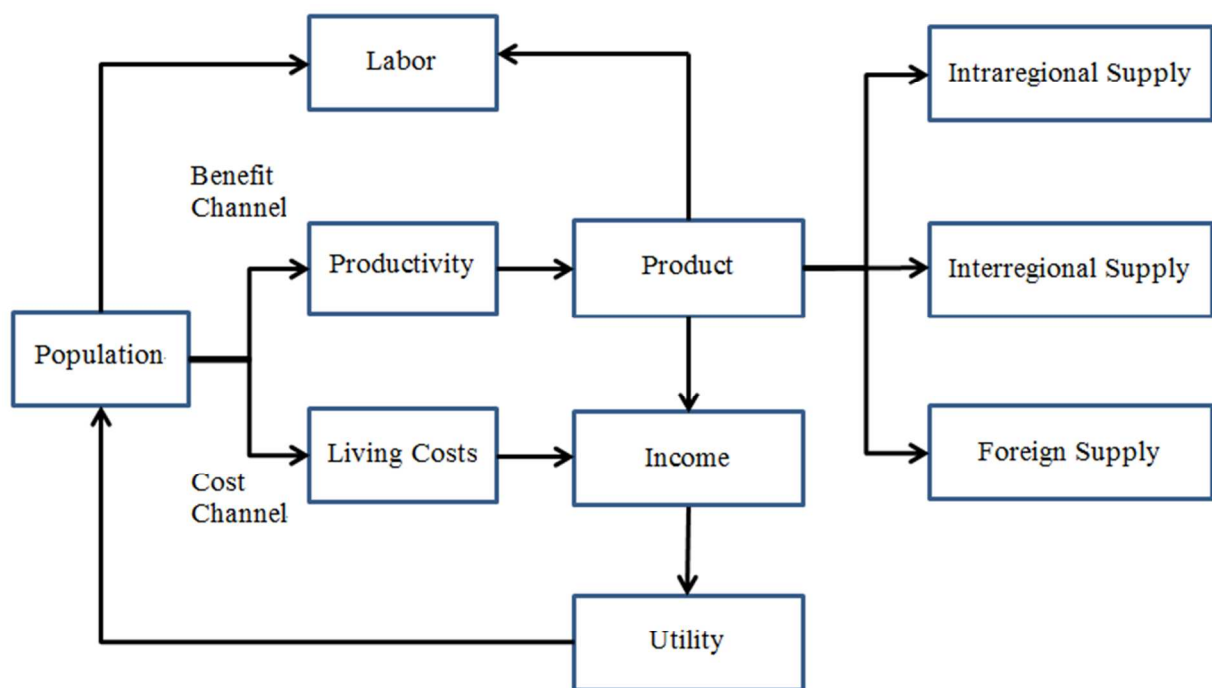
Figure 3: Positive and Negative Effects of Population Changes

   Table 3 displays our simulation results.   The table shows Korea's gross economic

performance corresponding to each counterfactual policy scenario in terms of its simulated GDP

to the level under the baseline scenario. Note that all of the numbers displayed in the table meet

the objective of maximizing Korea's GDP levels under given constraints. According to our

analysis, the Korean economy is estimated to reach a higher GDP level when the SMA's

population share falls below 40%, which is substantially lower than the baseline level (49-51%).

In detail, our simulation results show that Korea's GDP level was greatest at 39%, in terms of the

SMA's share of the national population, between 2006 and 2009. From a national perspective,

however, the SMA's optimal size slightly falls to 38% in the period from 2010 to 2014, and then

further drops to 35% in 2015. These results raise the possibility that the SMA's existing (or likely)

primacy has been (or will be) attained at the expense of reduced gross output at the national level.

In other words, Korea may be able to achieve the highest efficiency for its economy when the

SMA's baseline population level is reduced by 10% to 20%.

Table 3: Korea's GDP Levels by Scenario, 2006-2015 (baseline = 100)

Year	Counterfactual Scenarios (in terms of SMA's population share)											
	35	36	37	38	39	40	42.5	45	47.5	48	49	50
2006	112.75	113.82	114.47	115.11	115.29*	115.16	113.29	109.21	103.05	101.60	98.52	95.22
2007	115.03	115.97	116.53	117.09	117.22*	117.03	115.03	110.73	104.27	102.76	99.54	96.10
2008	117.36	118.17	118.64	119.11	119.19*	118.95	116.81	112.30	105.55	103.97	100.62	97.06
2009	119.67	120.35	120.74	121.13	121.15*	120.87	118.59	113.87	106.84	105.20	101.74	98.06
2010	121.94	122.49	122.81	123.12*	123.09	122.75	120.34	115.43	108.15	106.45	102.87	99.10
2011	124.15	124.58	124.81	125.04*	124.96	124.58	122.05	116.96	109.44	107.70	104.02	100.16
2012	126.24	126.55	126.70	126.86*	126.73	126.31	123.68	118.44	110.72	108.94	105.18	101.23
2013	128.23	128.41	128.49	128.57*	128.39	127.94	125.22	119.86	111.97	110.15	106.32	102.31
2014	130.09	130.15	130.15	130.16*	129.93	129.45	126.67	121.20	113.18	111.33	107.44	103.39
2015	131.81*	131.74	131.67	131.60	131.33	130.82	127.99	122.46	114.33	112.46	108.53	104.44

Note: * indicates Korea's maximum attainable GDP levels for each year under the given scenarios.

In contrast, the Gross Regional Product (GRP) could be maximized if the SMA's population

share is approximately 42-43% regardless of the period. For example, the GRP levels of the

SMA could increase by at least 10% to 34% compared with the baseline, as shown in Table 4.

This finding suggests that 35%-39% of the national population levels in the SMA would be

optimal for maximizing the Korea's total GDP, while 42%-43% would be optimal for

maximizing the total GRP of the SMA.

Table 4: SMA's GRP Levels by Scenario, 2006-2015 (baseline = 100)

Year	Counterfactual Scenarios (in terms of SMA's population share)											
	35	36	37	38	39	40	42.5	45	47.5	48	49	50
2006	38.50	93.39	97.58	101.76	105.07	107.71	111.07*	109.63	103.64	101.95	98.14	93.83
2007	90.73	95.68	99.92	104.15	107.50	110.16	113.46*	111.74	105.25	103.45	99.40	94.85
2008	93.14	98.14	102.43	106.72	110.10	112.78	116.00*	113.99	107.01	105.09	100.82	96.03
2009	95.65	100.72	105.05	109.39	112.81	115.49	118.63*	116.32	108.87	106.85	102.35	97.34
2010	98.24	103.35	107.73	112.12	115.56	118.26	121.31*	118.72	110.81	108.68	103.97	98.75
2011	100.85	106.00	110.43	114.85	118.32	121.03	124.00*	121.14	112.80	110.57	105.66	100.24
2012	103.39	108.58	113.04	117.51	121.01	123.73	126.64*	123.54	114.81	112.50	107.40	101.81
2013	105.86	111.09	115.59	120.08	123.61	126.35	129.22*	125.91	116.83	114.44	109.18	103.43
2014	108.24	113.49	118.01	122.53	126.09	128.85	131.70*	128.22	118.84	116.37	110.98	105.08
2015	110.49	115.74	120.29	124.83	128.41	131.20	134.04*	130.44	120.81	118.28	112.77	106.76

Note: * indicates SMA's maximum attainable GRP levels for each year under the given scenarios.

Given these results, how can we explain the gap between the actual and "ideal" (from a national perspective) sizes for the SMA? Table 5 suggests an answer to this question. As shown in the table, the per capita income levels remain higher in the SMA than in the ROK as long as the SMA's share in national population is within the range of 35%-48%. In particular, the SMA attains its greatest per capita income level—15%-17% higher than the national average—when its population share reaches around 40%. This fact suggests that the governments of Korea and the SMA may have different views of the SMA's optimal size: the Korean government is likely to see 36% of the national population as the SMA's ideal size, while the SMA's local government may be interested in maximizing the region's per capita or gross income levels by maintaining approximately 40% or somewhere between 40% and 49% of the national population (Figure 4). A market equilibrium point is likely to be between 48% and 49% in terms of the SMA's national population share, in which the SMA and the ROK reach comparable per capita income levels and residents of the ROK are thus no longer motivated to migrate to the SMA. The gap between this market equilibrium (48%-49%) and the SMA's baseline population levels (49%-51%) suggests that factors other than economic motivations—such as firms' preference for geographical

proximity to the central government due to easy access to public resources—are account for the

latter.

Table 5: SMA's per capita Income by Scenario (national average = 100)

Year	Counterfactual Scenarios (in terms of SMA's population share)												Base line
	35	36	37	38	39	40	42.5	45	47.5	48	49	50	
2006	110.29	112.09	113.31	114.42	114.92	115.00*	113.45	109.71	104.12	102.80	99.99	96.93	101.34
2007	110.43	112.30	113.56	114.71	115.23	115.31*	113.73	109.88	104.13	102.77	99.87	96.73	100.28
2008	110.56	112.49	113.78	114.96	115.49	115.57*	113.93	109.98	104.07	102.68	99.71	96.49	99.13
2009	110.69	112.67	113.98	115.18	115.71	115.78*	114.08	110.03	103.97	102.55	99.51	96.22	97.92
2010	110.83	112.84	114.16	115.38	115.91	115.96*	114.20	110.04	103.86	102.40	99.30	95.95	96.70
2011	110.96	113.01	114.33	115.56	116.08	116.12*	114.30	110.04	103.74	102.26	99.10	95.70	95.47
2012	111.09	113.16	114.48	115.73	116.24	116.27*	114.39	110.05	103.64	102.14	98.94	95.49	94.29
2013	111.21	113.30	114.63	115.88	116.39	116.40*	114.47	110.06	103.57	102.05	98.81	95.32	93.15
2014	111.32	113.43	114.75	116.01	116.52	116.52*	114.55	110.09	103.51	101.98	98.71	95.19	92.05
2015	111.42	113.54	114.87	116.13	116.63	116.63*	114.63	110.12	103.49	101.94	98.64	95.10	91.00

Note: Per capita income is measured as per capita GRP.
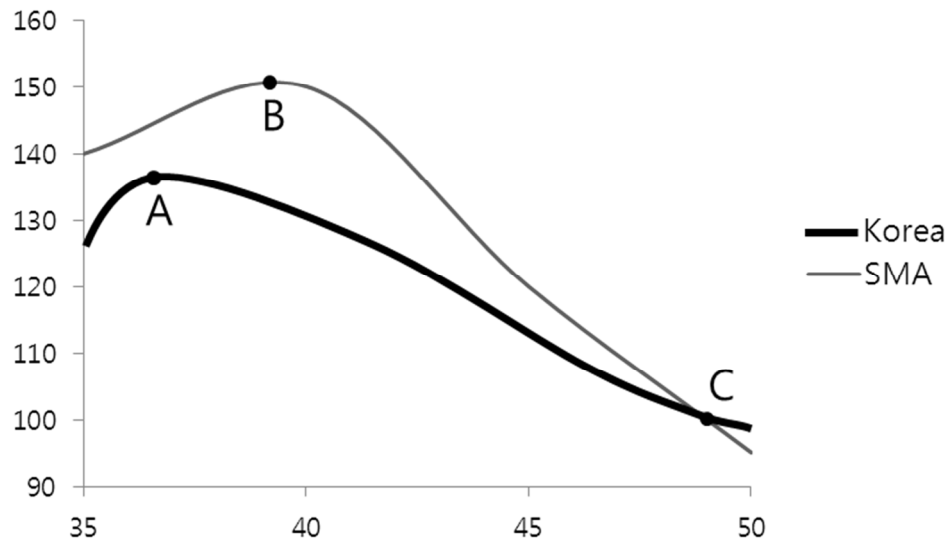* indicates the SMA's maximum attainable per capita GRP levels for each year under the given scenarios.

Figure 4: Korea's and the SMA's per capita GRP (unit: thousand US$)

Note: * 100 = GDP per capita with 50% of population share in the SMA.

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5. Discussion

Although our results provide some economic grounds to support public intervention to control the SMA's further growth, the question of *how to intervene* remains unanswered. Particularly tricky is how to guide the SMA to a certain growth path optimized from a national perspective while minimizing the sacrifice of its own economic welfare. As noted earlier, Korea's central government has implemented various policy measures to weaken market-reinforcing regional divergence forces, but most of them have failed to hinder the SMA's growth rate. Korea has learned from its past experience that strict growth-regulating measures targeting the SMA or simple resource reallocation in favor of the ROK would not be an ultimate solution to the divergence problem.

In this situation, the European experience may be worth noting. So far, the European Union (EU) has implemented comprehensive regional policies aimed at reducing gaps in economic opportunities across regions both at inter- and intra-national levels. Key measures of the EU's regional policies include structural funds and various capacity-building programs for backward regions, that are operated by using those structural funds (Faludi and Waterhout, 2002). As the EU's regional policy evolves, it places greater emphasis on capacity-building programs rather than on structural fund allocation among member countries. This suggests a policy framework shift from inter-regional income transfer to foundation-building for endogenous growth (Michie and Fitzgerald, 1997). This change was motivated by ample evidence showing that the early policies focusing on resource reallocation, although effective in reducing economic gaps among the member countries, failed to mitigate regional disparities within each member country (Boldrin and Canova, 2001; Cuadrado-Roura, 2001; Martin, 1998). In addition, the European regional policy framework has expanded the roles of local governments in their own economic

matters and encouraged public-private partnerships in planning and implementing the capacity-building programs (EU, 2007). In terms of content, the focus of these programs has been shifting from social overhead capital for agricultural or industrial production to local institutional capacity for learning or innovation. Promoting locally based education and R&D activities, for example, has been a major policy target. This shift corresponds to a new development paradigm in which human and social capital (or superstructure), rather than physical capital (or infrastructure), ultimately determines local economic performance (Putnam, 1993; Florida, 2002; Glaeser, 2011).

Empirical studies of Korea's regional disparities suggest that addressing the regional divergence problem would also require Korea to adopt such a paradigm shift in its regional policy (Kim, 2001; Park, 2001; Nam, 2009). Recently, there have been signs of such a shift; for example, substantial national resources that can be used exclusively for "balanced" national growth have been mobilized to fund various local development and capacity-building projects (Kim and Kim, 2007; Republic of Korea, 2002). Unfortunately, despite this new approach, evidence shows that regional disparities in Korea have become worse, placing emphasis on stimulating endogenous growth dynamics in the less prosperous regions rather than on suppressing the growth of leading regions. Thus, one may question the efficacy of the approach. However, rather than merely indicating the inadequacy of the policy paradigm itself, this result raises questions about implementation issues. For example, some argue that Korea can make its regional policy more effective simply by expanding the block-grant portion of the existing resource-reallocating system, as the current dominance of earmarked grants tends to allow excessive influence of the central government on local projects, making the regional policy too rigid to reflect local needs and policy goals (Koh, 2007). Moreover, the fact that fund-matching

requirements are rarely invoked inclines local governments to seek excess national resources with little consideration of their productive use to strengthen their endogenous growth base (*ibid.*).

6. Conclusions

Using the ICGE model, we analyzed the effects of regional population concentration on both national and regional economic growth. An optimal urban size corresponds to the trade-off a population experiences between the costs and benefits of regional living, such as that of agglomeration and congestion, and it is the point where the marginal benefit of the population is in equilibrium with the marginal cost. We found that the de-concentration of a population may contribute to the national economic growth, in the sense that the optimal urban size of the SMA is 38% of the total population in the short run and 36% in the long run. The current SMA population share of about 50% in the 2000s is higher than both short-term and long-term recommended population shares. The SMA, however, requires a 40% population share if it is to maximize its own regional per capita income, and a 48% share if it is to achieve maximum economic efficiency. This finding implies that, as long as the SMA population share remains under 48%, a rational person would move from the ROK to the SMA because the SMA's regional income per capita would be higher than that of the ROK. This quantitative analysis suggests that because the SMA is oversized from both national and regional economic perspectives, higher population concentration results in lower economic growth. This evidence resonates with traditional ideas regarding regional convergence over time, such as Wheaton and Shishido's (1981) claim that urban concentration increases in the first stage of national economic growth but decreases later as a result of an increase in national incomes.

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The field of economics has made several attempts to quantify empirically the optimal size of a spatial unit through the use of a general equilibrium structure. As such, a few points need to be mentioned regarding the prospect of further research on optimal size issues. First, the suggested optimal population size is derived from the economic context of specific domestic regions. As international competition increases among major city-regions, such as Beijing, Shanghai, and Tokyo in the Northeast Asian countries, an optimal population size will need to be recalibrated to account for these international economic developments. For example, reducing the SMA's population share for the sake of improving the economic efficiency of the Korean domestic market may simultaneously hinder the ability of the SMA to compete in the Northeast Asian economic region.   The model would need to be specified with a partition of the rest of the world into some of the regional cities highlighted.   In essence, a bi-level multi-economy CGE might be required with inter-country metro competition at the top level and the intra-country (Korea) partition of the current ICGE model at the next level.

Secondly, it appears possible to take into account the various external costs and benefits in the modeling process. This paper focused only on pecuniary economies, such as labor wages and values, in measuring the costs and benefits of agglomeration. However, decisions regarding migration and the relocation of economic production could be more dependent on consumption externalities and locally specific amenities, such as the quality of commercial and medical services, education, neighborhood, and even climate. Another extension of the present work may be to modify the cost and production functions by developing a channel of technical changes and innovation in a dynamic framework. The current model has some dynamic specifications—such as capital stock-investment, flows of the capital accumulation, and migration-natural growth for the population module—but it cannot accommodate parameter changes within the production

module. For example, the introduction of new transportation modes and improvements in the logistics may lead to flatter slopes of the cost and benefit functions for a population, which may result in a higher optimal population share than suggested by this paper's findings.

Finally, it would be interesting to measure the efficient and optimal size of a working population according to age, since an aging population is an issue faced by many countries. Shifts toward an aging demographic may mean that the total size of a given population will come to matter less for urbanization economies due to negative economy-wide effects, such as a reduction in savings and increases in private consumption and public pension payments.

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