Does Immigration Benefit a Regional Economy With An Aging Population?: Simulation Results from the Chicago CGE Model

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Abstract

Immigration has become one of the most debated topics because it has both positive and negative impacts on the host economy. This research is motivated by the conflicting evidence that has been assembled on the longer-term impacts of immigration on a regional (metropolitan) economy that is experiencing a demographic transition to an aging population. The research proposes to answer the following set of questions which were not properly answered in the previous studies: (1) How would the immigration mitigate the problems associated with aging population? (2) How would the policy mix affect the benefits of the immigration? (3) What would happen to income disparities with an increase in immigrants? And (4) How sensitive will the welfare effects be to changes in the size of immigration?

The main contribution of this study is to evaluate these questions at the regional level as the first case study of this kind in the US. To address these issues, this study uses a two-region Computable General Equilibrium (CGE) model, where all the economic interactions arising from demographic changes caused by aging population and immigration can be captured since the model contains detailed information about all commodity and factor markets together with each agent's decision making process. The results reveal that immigration plays a critical role in maintaining labor force levels and through immigrant contributions to social security payments. The income distribution appeared to worsen with the higher immigration, while the welfare of all the populations is improved. Regarding the issues of the policy mix to maximize the regional welfare, a larger number of immigrants does not necessarily result in more desirable results. Instead, the result suggests that the regional welfare is optimized when the local government admits immigrants up to the national average. Further, pension reforms generating small benefits turn out to reduce the potential benefit of local immigration.

1. Introduction

Immigration has become one of the most debated topics because it has both positive and negative impacts on the host economy. As a result, a large volume of academic research surrounding the immigration over the past decades provides a valuable lesson that the impacts of immigration will differ for different places and different times, and could be either beneficial or costly (Borjas, 1994). However, there is relatively obvious consensus that immigration might be the most important policy measure to prepare for the problems associated with serious demographic imbalance caused by an aging population, the impacts of which will be most critical over the next several decades. Most studies suggest that immigration could make a significant contribution to economic growth of the host region by making up for the decline in the size of the labor force. Especially, with the expanded role of the social security system under an aging population, the fiscal implications of immigration will be very large and positive because immigrants immediately pay social security taxes, which would otherwise have to be sharply increased.

In similar fashion to more recent studies, this one examines the impact of immigration under a general equilibrium framework. However, in contrast to previous work, this study includes complicated issues that should be addressed for the more detailed, comprehensive evaluation on the desirability of immigration policy under aging population. The first issue is that if the government handles the aging population by implementing the policy mix that includes adjusting retirement benefits, changing the retirement age and altering the volume of immigration, the benefits of the immigration might be radically altered over the next a few decades. In most findings supporting immigration as a unique policy instrument, many of the benefits of immigration have been generated from the reduced tax burden, which in turn increases the

availability of private saving. However, if immigration is considered together with pension reform that is oriented to a more pre-funded system, the benefit might be substantially decreased because the effect of pension reform on reducing the fiscal deficits may offset considerably the potential benefits of increasing immigrants. On the contrary, the adverse impacts on the local labor market outcomes for low skilled residents are relatively much stronger than the labor supply shocks associated with immigration. The second issue that the previous studies did not address is the income disparities among individuals. It is clear that inflows of new immigrants could make a contribution to raise the income inequality by putting downward pressures on the income of low-skilled workers, who mainly rely on their wage income. However, since the aging population puts upward pressure on wages (reflecting the relatively scarcity of labor supply), the overall impact on income inequality depends on the relative magnitudes of the upward and downward pressures. The third issue is related to the intergenerational welfare effect. The cost and benefit of immigration will differ significantly between the young, middle-aged or retirees. Especially, large losses are expected to the young generation who generally have a lower level of productivity. However, in the case of an aging population, the situation is not as simple as the previous case due to the contribution of immigration to reducing the heavy burden of the social security system whose funding (through taxes) will fall disproportionately on the current young generation without the help of immigrants. Nonetheless, there were few findings suggesting the potential implications on intergenerational welfare effects of immigration. The last issue, but the most important contribution of this study, is the lack of analysis at the regional level. The literatures investigating the economic impact of immigration at the national level have grown explosively since 1980s and substantially sharpened our understanding of the economic impacts of immigration. However, the results may not apply at the regional level;

there could exist diverse regional effects in the presence of various regional differences based on economic and demographic structures. For example, the wage and employment effects of immigration may not be the same as those observed at the national level, because interregional migration in response to immigration due to crowding out in the local labor market might result in different outcomes.

To address these issues, this study uses a two-region Computable General Equilibrium (CGE) model, where all the economic interactions arising from demographic changes caused by aging population and immigration can be captured since the model contains detailed information about all commodity and factor markets together with each agent's decision making process.

For this study, Chicago region[1] is selected for a reference region since it has long been both a leading immigration destination; further, it is expected to face a significant demographic change with increasing retirement out-migration as the population ages over the next two decades. Over the last three decades, Illinois has lost its place as one of the leading states in the national economy. Traditionally, Illinois had been one of the highest per capita income states, ranking among the top ten states with the income much above the national average. However, in 2005, Illinois' per capita income fell to just slightly above the national average, ranking fifteenth highest among the states. This decline has been more serious when economic performance has been viewed in terms of total income rather than in per capita terms. About thirty years ago, the Illinois economy accounted for 6 percent of national income; by 2005, its share had fallen to 4.5 percent. Much of this economic downturn is linked to the metropolitan Chicago economy, which plays an important role as a development engine for the state, accounting for about 65 percent of state population and over 70 percent of state production. There can be little doubt that the lower

[1] The Chicago area is the MSA, comprising the counties of Cook, Will, DuPage, McHenry, Lake, and Kane.

level of relative economic performance of both Chicago and Illinois partly resulted from the recessions in the manufacturing sector starting from the early 1980s. Since 1990 alone, the state has lost 231,000 manufacturing jobs at a rate that is almost twice as high as that for the Midwest as a whole. However, the steady decline in economic performance over the long term could be convincingly demonstrated by the slow population growth and changing structure of population in this region. Although international (legal and illegal) immigration is an increasingly important component of national population change, regional demographic structure is determined by the combination of natural increase (births – deaths), and two types of migration, international and interregional. However, as regional fertility and mortality have become more uniform throughout the United States, migration has become by far the more important factor in changing regional populations. Hence, part of the reason for the slower pace of population growth in Chicago might be explained by the outcome of the out-migration of native workers in manufacturing sectors which have been replaced with immigrants who have lower productivity.

This paper is structured as follows. The next section introduces the detailed model structure including some technical issues. Thereafter, a description of the data and calibration will be provided in the section 3. In section 4, numerical impacts of immigration under aging population and policy mix are evaluated. A brief summary completes the paper.

2. Method[2]

This model is represented by the two-region dynamic general equilibrium model with an overlapping generations framework, whose national version was originally developed by

[2] A full description of the model is available at Park (2007)

Auerbach and Kotlikoff (1987). Like the former model, this model incorporates individual earnings heterogeneity, demographic transitions, and a social security system. However, there are some novel features that differentiate it from former overlapping generations framework in two ways. First, this model newly introduces regional elements which are omitted in the national overlapping generations framework. In this model, each region is interlinked with each other by migration, trade, and the social security system. Secondly, unlike Fougere *et al*. (2004), this model features age-specific mortality and borrowing constraints which are critically important to generate realistic implications of the effects of demographic changes. Detailed features are presented in the following section.

2.1. Regional Setup

The model economy is composed of two regions, Chicago (HOME) and rest of the US (ROUS), but the basic structure of this regional model is closely related to its national counterparts. Households[3] maximize their utility by choosing a profile of consumption over the lifecycle and firms demand factors following from profit maximization, responding to differences in goods and factor prices. Prices adjust in both goods and factor markets to clear the excess demand.

However unlike the prototype of OLG model, this model has a complicated structure, even more than international trade models. This model adds various components and linkages into its national version to capture the regional features. First, labor is assumed to be partially mobile in domestic regions, while internationally immobile, taking into account people's preference for

[3] Since each household consists of one agent in this model I will use household and individual agent interchangeably.

staying in the region where they originally reside[4]. This locational preference is represented by the wage elasticity of labor migration. With partial mobility of the labor, wage differentials between regions take multiple periods to adjust because of the lagged responses of labor market. However, capital is assumed to be immobile interregionally[5]. This results in the return on capital being different across the regions.

Secondly, the nesting structure is necessary to complete the household's decision process, since both regions trade in goods and each individual considers products from different regions as imperfect substitutes following the familiar Armington assumption. Under the Armington assumption, a good produced in one region is treated qualitatively different from good produced in other regions. Thus, the Armington assumption ensures that consumers demand all the goods produced in both regions. The hierarchy in nesting structure of this model consists of the following two steps. In the first step, each agent determines the aggregated consumption path over time, maximizing a time-separable utility function subject to lifetime income. Time separability allows a separation between intertemporal and intraperiod decision-making in the nesting structure. Once optimal conditions governing the aggregate consumption levels are established, the next step is to allocate these expenditure levels among differentiated good in terms of geographic origin, i.e., home produced good and imported good from rest of the U.S. In this step, substitution elasticities play an important role in determining each agent's optimal choice; thus, the values of elasticities between two regions are very important to influence the magnitude of the regional effects. For example, even if the aging population changes the age structure in a similar pattern across the nation, the effect on regional economies will depend on

[4] According to Jones and Whalley(1986), perfect labor mobility is not useful in analyzing the region specific effect of government policies because under perfect mobility, the policy effect might be underestimated with complete labor movement between regions.
[5] The treatment of capital mobility is important when assessing the regional investment policies.

these elasticities.

2.2. Dynamic Overlapping Generations Framework

To measure the effects of the demographic change on the behavior of different generations, it is necessary for the model to be disaggregated by the age cohorts as well as dynamic processes, describing the path of consumption and savings behavior of each age cohort over time. The dynamic overlapping generation framework satisfies these criteria and employs the framework developed by Auerbach and Kotlikoff (1987). There are three types of agents in each region: households, firms, and government. Each sector represented by these agents has stylized components, but their interactions can be quite complex. By solving for the economy's general equilibrium transition path, the model takes into account all relevant feedbacks among these agents according to demographic changes and relating government policies.

In this model, each region is populated by individual agents who live up to age 85. This limited age does not appear to be crucial since, under this assumption, less than 3 percent of the U.S. population is not considered.[6] The individual agent enters the labor market at the age of 21 and retires mandatorily at the age of 65. Since all the individuals between ages 0 and 20 are considered not to perform economic activities, reflecting they are supported by their parents, this model deals with only the individual agents above age 21. Lifetime uncertainty is considered in this model, i.e., each individual faces a different probability of death in every period, which becomes higher as they age. Therefore, in every period, some fraction of people dies earlier than

[6] Of course, all of these stylized facts can be changed and part of the research agenda will be to consider changes.

age 85, and leaves accidental bequests since annuity markets are assumed to be missing.[7] Total accidental bequests are distributed evenly over all the agents alive in the next period. Moreover, each individual is assumed to face borrowing constraints. Under borrowing constraints, social security could further distort the intertemporal consumption allocation by levying the higher payroll tax on younger generations who are binding in borrowing constraints.

Individuals are endowed with one unit of time and supply their labor inelastically. Since all agents in the same age cohort are identical in terms of preferences, individual heterogeneity is present only across age cohorts with respect to labor productivity and wage income depends on the individual's productivity, which is assumed to be identical across regions. However, wage income might differ across regions because the wage rate per unit of effective labor is region-specific due to the partial labor mobility. Because of wage differences by age, the income life cycle of an individual is described by a hump shaped income profile. The individual agent starts to work at age 21 and receives the highest wage income during his/her middle age. Retirement terminates the flow of wage income and entitles the individual to pension benefits. As a result of the uneven pattern of wage rates over their working lifetime and borrowing constraints, individuals save during middle aged working periods and dissave in retirement, which results in uneven distribution of wealth by age cohorts.

3. Data and Calibration

One of the key issues in computable general equilibrium modeling is calibration, which is the process of selecting values of exogenous parameters to ensure that the solution is consistent with

[7] With perfect annuity markets, each individual does not leave unintended bequests. However, social security system substitutes partially for missing annuity system and reduces unintended bequests.

what is observed in the data. The calibration of the model is basically conducted to replicate the equilibrium conditions in the base year, 2005 in this model. Since national values are easily obtained from the accessible national data set like NIPA and previous studies (Brown, *et al*., 1992; Kouparitsas, 1998) the following mainly describes the choice of regional parameters.

Steady state conditions and microconsistent data set for the Chicago region are mostly obtained from the Chicago Social Accounting Matrix (SAM) constructed by MIG (1997), Illinois input-output multipliers and Chicago input-output tables prepared by REAL (Regional Economics Applications Laboratory) in the University of Illinois. Further, a computable general equilibrium model for Chicago region with a single representative household has been completed and many of the parameters for this model are used in the two-region system.

Some regional parameters which appear in the utility and production functions are obtained from the corresponding national counterparts since the model assumes the same type of household preferences and production function across regions. For example, the coefficient of relative risk aversion is chosen by γ=1.91[8] following the estimates established by Hurd (1989) and Imrohoroglu *et al*. (1999). The subjective discount factor is chosen by $\frac{1}{1+\rho}$ =1.011 following the suggestion of Imrohoroglu *et al*. (1999) to reproduce a reasonable wealth-output ratio. Both preference parameters generate the wealth-output ratio of 2.89, which is slightly lower than the empirical measurement of 3.15 by Laitner (1992). The production parameters are calibrated along the lines suggested by previous studies. The depreciation rate (δ) and the technology parameter (A) for both Chicago region and rest of the US are set at 0.069 and 1.005,

[8] Mehra and Prescott (1985) suggest that the coefficient of relative risk aversion is between 1 and 2.

respectively. The labor share of output (α) for Chicago region is calibrated using Chicago SAM, yielding a value of 0.66, compared to 0.69 for rest of the US.

For the demographic data set, population change by age cohorts until 2050 is obtained from the projections provided by U.N. and Illinois Department of Commerce and Economic Opportunity. The conditional survival probabilities (s) are taken from Faber (1982). This implies a dependency ratio results in a dependency ratio of 17.7 percent in the base year, which is close to a ratio of 17.8 percent based on the U.S. census data for year 2005. Over the demographic transition periods, the dependency ratio calibrated in the model closely approximates to the one from the U.N. projection. The labor earning's profile is taken from Hansen (1993) and Miles (1999).

Also, the price elasticities in interregional trade are assumed to be the same as those in international trade following the suggestion by Jones and Whalley (1989). The labor migration elasticity is specified at 0.137, reflecting the past studies on interregional migration (Plaut, 1981; Seung and Kraybill, 2001). The pension replacement rate for the base year is taken to be 50 percent of the average wage income, which matches its empirical counterpart[9].

4. Simulation Results

4.1. Increasing Immigrants

Immigration has both positive and negative impacts on the host economy. One of the biggest costs that the immigration may create is the adverse effects on local labor market because it

[9] Conesa and Krueger (1998) computes the replacement rate of 50 percent using social security payroll tax and OASI (Old-Age Survivors Insurance) data of the U.S.

could reduce the wages and exhaust employment opportunities of native workers, especially for those who are young and have low skills. Also, high income disparity could be generated due to the large decline in income of low-skilled workers. On the other hand, however, immigration fundamentally changes the age structure, and is very helpful in contributing to a solution to the demographic imbalance caused by aging population. Also, one of the most common arguments in favor of immigration is that it will significantly alleviate the solvency problem of the social security program because immigrants pay social security tax, and usually have no parents who are currently drawing on the system.

Over the past decade, about 800,000 legal immigrants have been newly admitted in the United States every year, according to the Department of Homeland Security. Among U.S. states, Illinois has long been a major immigrant settlement place as fifth leading immigrant-receiving state. It has admitted the nearly 0.4 million legal immigrants over the last ten years. This is an average of 40,000 immigrants per year. The cumulative total of legal immigrants in Illinois between 1965 and 2002 has been about 1.3 million. In addition, according to the Immigration and Naturalization Service (INS), over 0.4 million illegal immigrants reside in Illinois, and most of them are concentrated in the Chicago region. Among these immigrants, more than three-fifths (64.7 percent) of all immigrants since 1993 came from Mexico, Poland, India, Philippines, former Soviet Union, and China. Mexico alone accounted for nearly one-quarter of all new immigrants (24.8 percent). This continuing influx of new immigrants will account for a much more significant share of Chicago's population. Moreover, the number of

newly arrived immigrants in Chicago region is expected to increase thanks to the recent introduction of a medical support program.[10]

In this respect, this section assesses the potential impacts of inflow of immigration into the Chicago region. Simulations for impact analysis are conducted through the following three scenarios, which are differentiated by the size of immigrants for both regions; Chicago and rest of the U.S. Scenario 1 assumes that each region admits new immigrants amounting to 0.6 percent of the regional population every year, which is equivalent to the historical average of immigrants admitted in the Chicago region between 1993 through 2002. Scenario 2, in contrast to the first scenario, assumes that the only Chicago region admits more immigrants, while rest of the US fixes the share of immigrants at 0.6 percent. That is, in Scenario 2, the proportion of newly admitted immigrants into Chicago region is adjusted to 1.2 percent of the population, or about 0.1 million.[11] Scenario 3 assumes that the local government for Chicago adopts more favorable immigration policy where the number of annual immigrants admitted in the Chicago region increases to 1.5 percent of its population, or about 0.12 million. According to these scenarios, the dependency ratio in Chicago region is expected to be substantially reduced over the next several decades. For example, before the immigration, the model projects a significant increase in the dependency ratio from 19 percent to 32 percent over the next 30 years, whereas new immigrants admitted according to Scenario 3 contribute to dropping the dependency ratio in 2030s to 19 percent, which is the same level as before the aging population. Taking into account the characteristics of immigrants, who are young and low-skilled, newly admitted immigrants are assumed to be equally distributed over between the age of 21 and 35, whose average productivity

[10] Recently introduced medical support program, which provides comprehensive health insurance for every child of low income families including all immigrants, could attract more immigrants into Illinois state.
[11] Storesltten (2000) found that the minimum number of immigrants required to balance the fiscal budget is 1.08 percent of the population in the US.

is about 60 percent of the peak at 47 years of age. The baseline Scenario, whose results are compared with Scenario 1 through 3, assumes an aging population with no immigration.

Figs. 1 through 9 summarize the main results for this simulation. Figs. 1 and 2 plot transitional profiles of capital/labor ratio and wage, respectively.

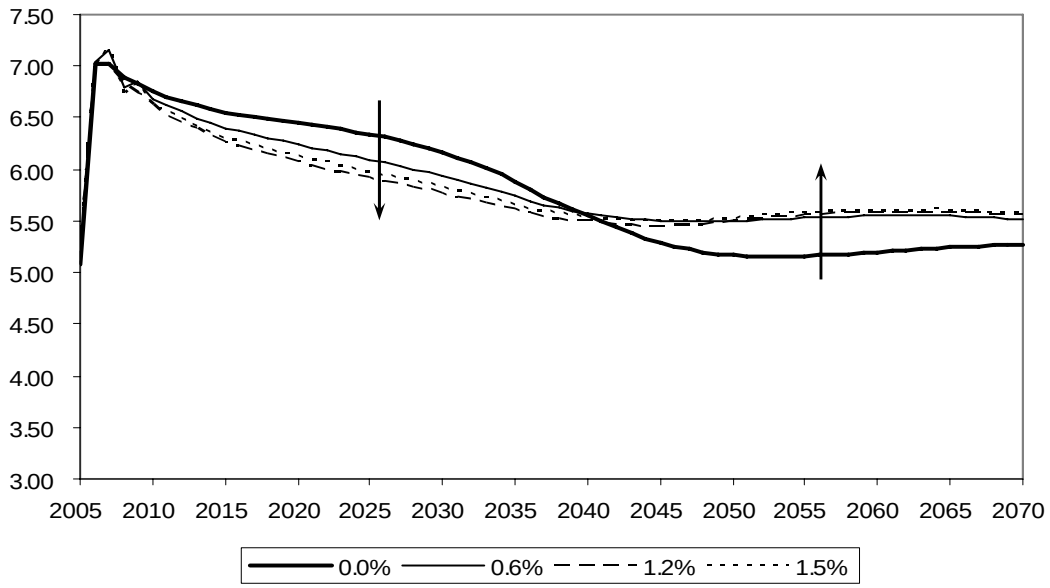

Fig. 1. Simulation results of immigration policy: Capital/labor ratio (Chicago)

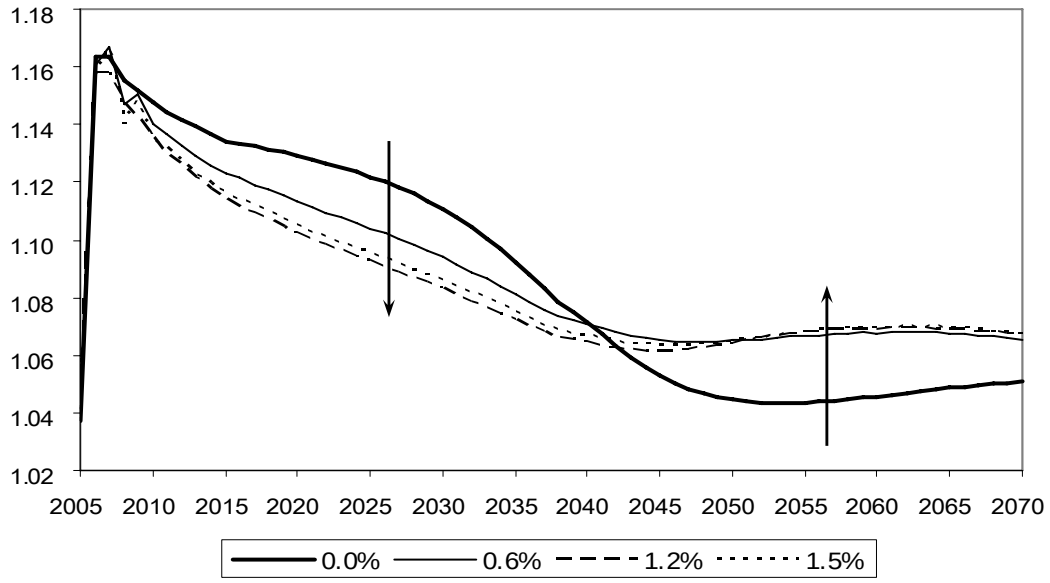

Fig. 2. Simulation results of immigration policy: Wages (Chicago)

The inflow of young immigrants, initially, lowers the capital/labor ratio, which in turn contributes to a decrease in wages. However, after the initial period, the fall in capital/labor ratio corresponding to accumulating immigrants declines and stops at around 2040, which is 5 years earlier than the case of the baseline. After 2040, the wages under favorable immigration remain higher than the baseline case. This result is somewhat counter intuitive because large immigration should be expected to exert a strong downward impact on wage. One possible reason for this result is because the first immigrants start to retire around 2040s, resulting in an increase in the capital/labor ratio. However, there are two more important factors at work for this result to happen. The first factor is that the more immigrants that are admitted the more native workers can save since immigrants will significantly reduce the social security tax burden. Next, at the time of immigration, it is assumed that capital does not flow into the host country with immigration, but once immigrants start to work and acquire higher levels of productivity, they can accumulate more savings, thereby increasing aggregate capital stock. These dynamic

changes of the capital/labor ratio over the transition period might imply different effects of immigration between the short run and the long run.

Fig. 3 shows how the regional output would be changed by immigration streams over time. According to the simulated results, an increase in immigrants appears to have more positive impacts on regional output growth. For example, in the case of the maximum contribution by the most favorable policy (Scenario 3), the Chicago region appears to grow annually by 0.9 percent between 2005 and 2070, while without immigration it will face negative growth (-0.2 percent per year) over the same period due to aging population. This result can be fully expected because immigration provides a positive labor supply shock to the local economy.

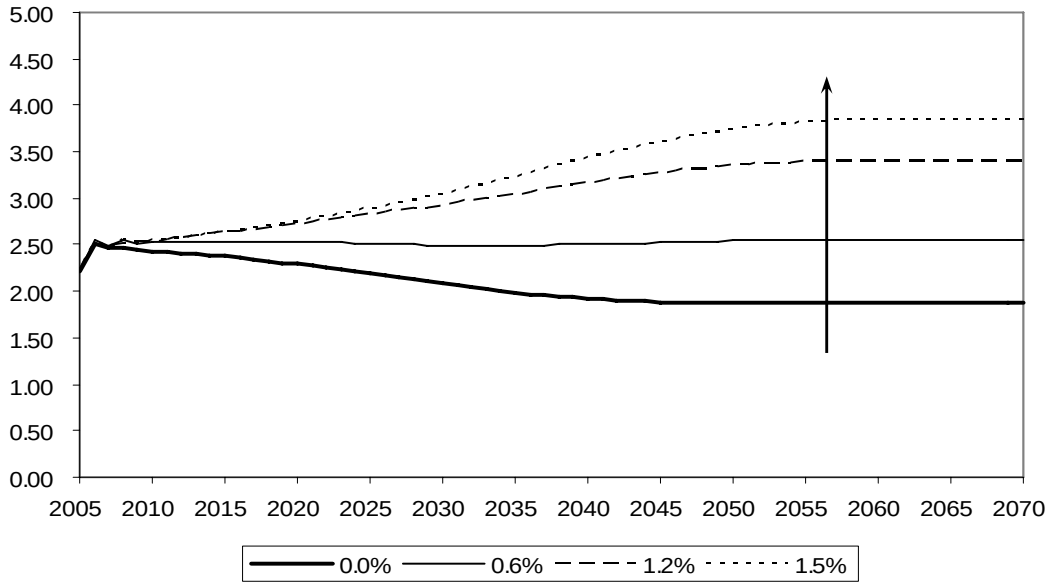

Fig. 3. Simulation results of immigration policy: Gross regional product (Chicago)

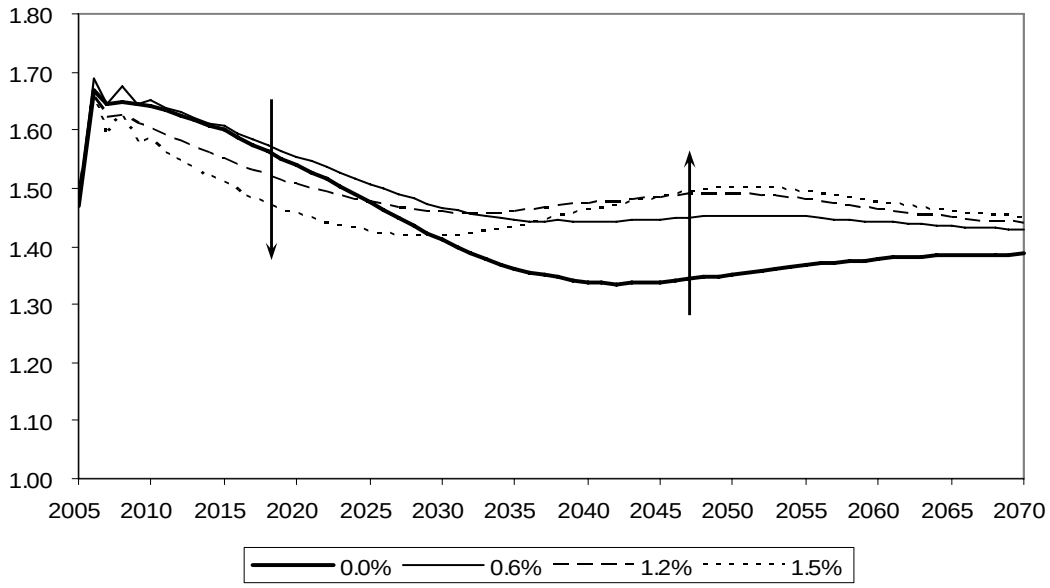

Fig. 4. Simulation results of immigration policy: Per capita GRP (Chicago)

However, the transitional profile of per capita GRP is not similar to that of aggregate GRP as shown in fig. 4. During the initial period, relatively larger immigration, such as proposed in Scenario 2 and 3, keeps the per capita GRP remaining at a lower level than that of the baseline case because the immigration increases only low-skilled workers. However, after 2030s, when the first immigrants really begin to acquire higher levels of productivity, per capita GRP turns to an upward trend and grows faster than in the baseline case. This positive trend also substantially contributes to reducing the decline of per capita GRP under an aging population. For example, between 2005 and 2070, the negative 5.5 percent per capita GRP growth under an aging population is reduced to, negative 2.6 percent (scenario 1), negative 1.9 (scenario 2)and negative 1.2 percent (scenario 3). The national GRP share of the Chicago region (fig. 5) noticeably increases from 3.0 percent to around 3.5~4.0 percent in Scenario 2 and 3 because both scenarios assume relatively higher share of immigrants are admitted only in the Chicago region.

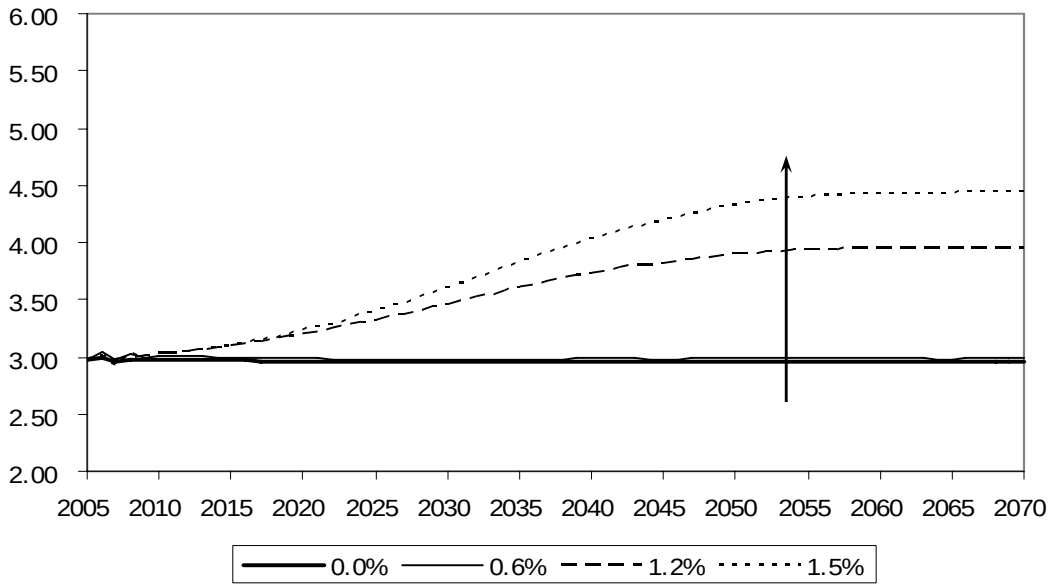

Fig. 5. Simulation results of immigration policy: GRP share (Chicago)

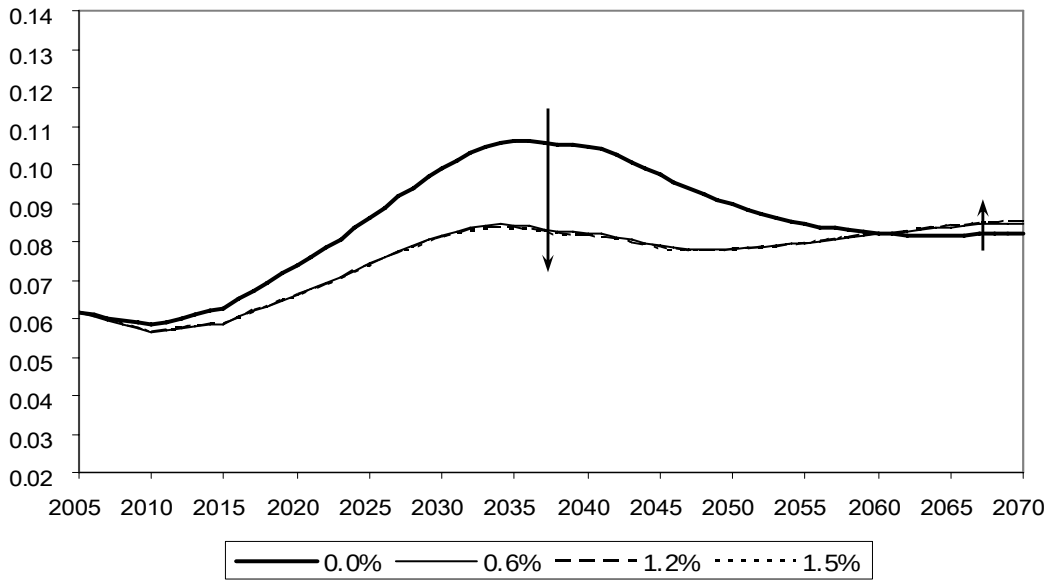

Fig. 6. Simulation results of immigration policy: Social security tax rate

The projected effect on the social security tax rate is shown in fig. 6. Not surprisingly, a larger number of working-age immigrants appears to have significant downward impact on social security tax rate. Thanks to this downward pressure, in 2050, the social security tax rate is projected to return to the level of before an aging population. This is one of the significant benefits that large immigration will bring about. However, on closer inspection, the benefit for social security system is reversed when the immigrants start to retire. After 2050, the social security tax rate starts to increase and eventually converges to around 9 percent which is higher than the rate expected under no immigration. This result shows the opposite aspect of the immigration; as immigrants age, like everyone else, a sustained policy of immigration has little long-run impact on the age structure of the population, and thus its benefit declines. Another important policy implication, especially for the local (Chicago) government, arises from the different stance on immigration between federal and local governments. In case of Scenario 2 and 3, only the Chicago local government optimistically admits more immigrants than the national average. However, the social security tax rate changes insignificantly because the additional working-age immigrants in Chicago region are not of a significant size to decrease the tax rate which is influenced by the changes in national population. Therefore, locally increased immigration may only hurt the local labor market without generating additional tax benefits.

Figs. 7 and 8 present the effects of immigration on both income and asset distribution, respectively. Immigration turns out to have a negative impact on equality in terms of income distribution, i.e., income Gini coefficient becomes larger as more immigrants are admitted. This can be explained by the following two reasons. First, young lower income groups substantially rely on labor income, while middle-aged populations earn large income from both asset holdings and labor earnings. Thus, younger populations become even poorer as more immigrants

decrease wage income, whereas rich middle-aged populations are not much affected by the immigration because they earn large capital income thanks to the increases in the interest rate. The second reason is closely related to the change in demographic structure associated with immigration. Before the first immigrants start to retire around 2040s, the share of large income population increases relatively faster than young and old poor populations because more immigrants acquire higher skills and become richer. This structural change in population increases the aggregated income gap between middle-aged rich population and poor young and old populations. However, after 2040s, since wages start to increase and immigrants start to retire, the Gini coefficients in all immigration scenarios starts to fall. Unlike the income distribution, immigration improves the equality of asset distribution until mid 2030s, i.e., the asset Gini coefficient falls.

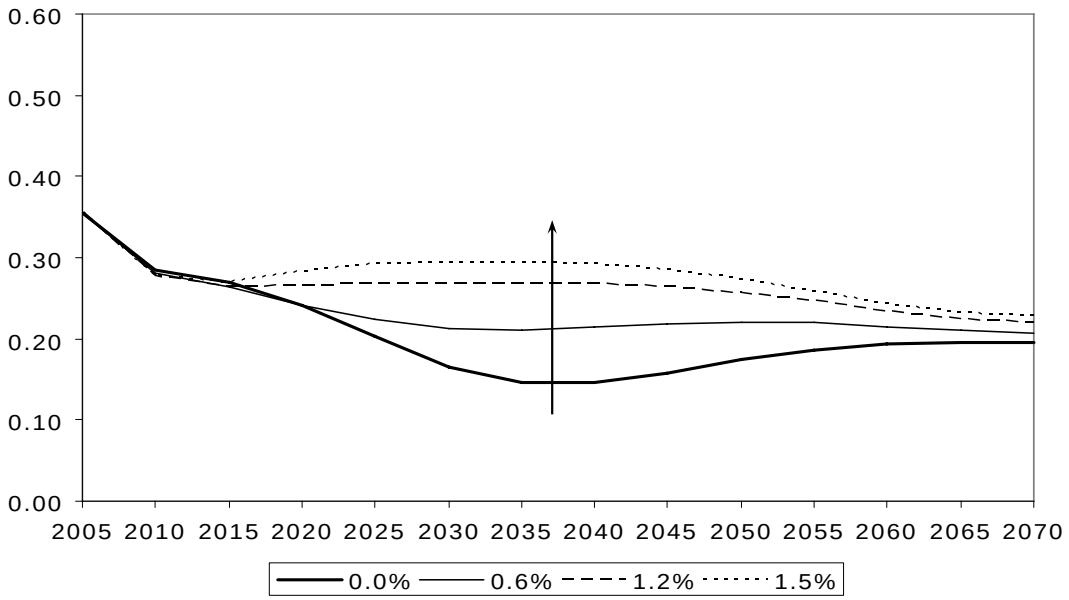

Fig. 7. Simulation results of immigration policy: Income Gini coefficient (Chicago)

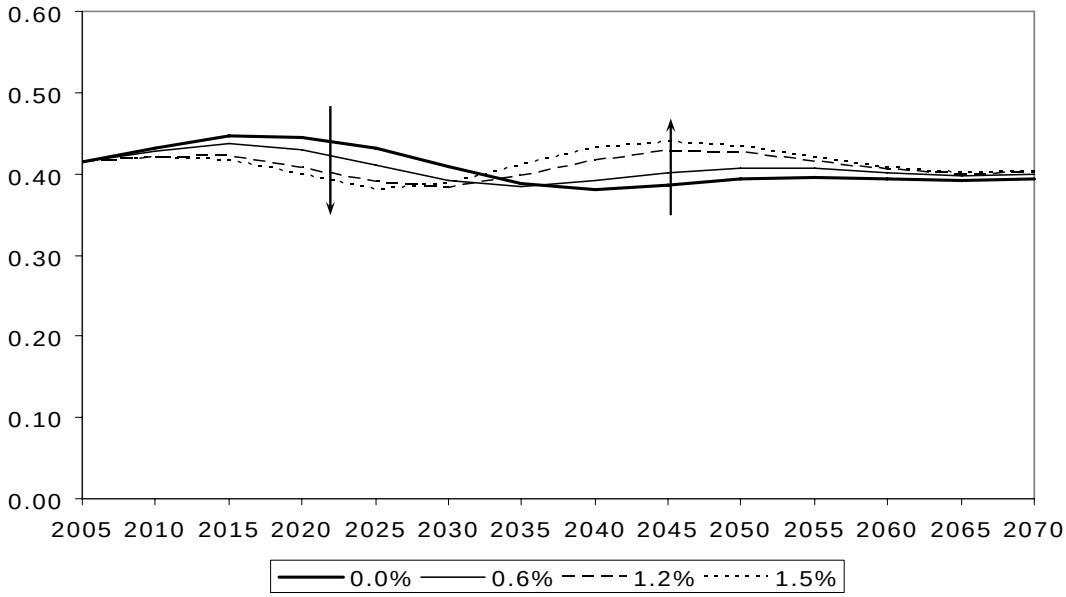

Fig. 8. Simulation results of immigration policy: Asset Gini coefficient (Chicago)

However, the effect of immigration on asset distribution is reversed during the subsequent period. Basically, immigration has an upward pressure on asset Gini coefficient since it increases the asset holdings of the wealthiest group without significant changes in asset holdings of younger generations who face liquidity constraints. However, in the initial period, the increasing number of younger populations associated with new immigrants drives the asset Gini coefficient down, reflecting the reduced gap of the aggregate asset between middle-aged wealth population and young poor population.

Fig. 9 shows how the welfare effects of the immigration vary over the transition periods.[12] The welfare benefit is measured by a consumption equivalent variation (EV),[13] which computes

[12] Welfare effects of the policy reforms between steady states, which does not consider the welfare changes during the transition periods, are reported in the next section.

[13] Equivalent variation is calculated as $EV = \left(\frac{v(a, j, t+1)}{v(a, j, t)} \right)^{1/(1-\gamma)}$, where '*a*' is asset holdings, '*j*' is age, and '*t*' is time

the consumption change required to keep the expected utility in the initial condition equal to that achieved in new condition under immigration policies. Given the form of the utility function, positive (negative) EV implies that long term benefit (cost) in terms of welfare would be provided as a result of more favorable immigration policies. According to the simulation results, the current young populations appear to be the major gainers of the favorable immigration policy. The rationale for this is that even with the wage declines in the initial period, the prospect of higher disposable income for the rest of their lives obtained by both increased interest rates and reduced social security tax outweighs the negative effect from the wage loss. This is good news for current young generations. However, unlike the assumption of this model, if more immigrants fail to adapt to conditions in the host region's labor market, and thus, remain lower skilled workers, then immigration cannot make a sufficient contribution to increasing tax contributions.

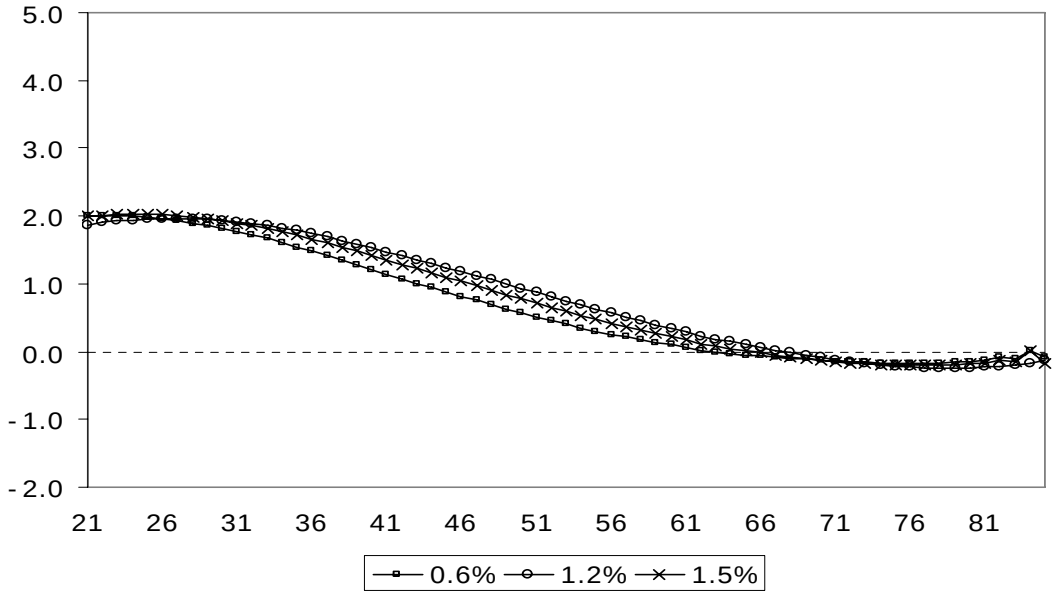

Fig. 9. Simulation results of immigration policy: Equivalent variations (Chicago)

4.2. Immigration and Pension Reforms

The impacts of immigration as in the previous section might be radically altered when two or more policies are implemented at the same time, such as, immigration and pension reform. For example, in most findings supporting immigration, many of the benefits of immigration have been generated from the reduced social security tax burden, which in turn increases the affordability of consumption and leads to a more desirable age-consumption profile. However, if immigration is considered together with the pension reform toward a more pre-funded system, the benefit might be substantially decreased because the effect of pension reforms on reducing the social security tax rate may considerably decrease the potential benefits which immigration policy expects. Then, the benefits of immigration are rapidly offset by the cost associated with wage loss.

In this respect, this section analyzes the optimality of policy combinations and suggests the optimal mix. For this purpose, this section simulates policy mix between immigration and pension reform. This simulation explores the policy implications for the local government to maximize the benefit from the differentiated immigration policy of the federal government under the situation where federal government also implements other policy measures; pension reforms.

Optimality is evaluated by welfare changes as in the previous section. However, there is a difference in welfare measures. In the previous section, consumption equivalent variation is used for quantifying the welfare changes by age cohort, but it does not represent the overall welfare of the population as a whole. However, in order to find the optimal policy mix, we need a measure of average utility which considers all age cohorts. In this study, following

Imrohoroglu *et al*. (1995), the average utility[14] is measured by the expected discounted lifetime utility of a newly born individual under a given policy mix.

Table 1 presents the welfare changes corresponding to various combinations of immigration shares and pension benefits. Each row in the table represents four different shares of newly adopted immigrants out of total regional population, which are increased by 0.6 percent from no immigration to 1.8 percent. As in the previous simulations, it is assumed that only the Chicago local government adopts more favorable immigration policies, such as 1.2 percent and 1.8 percent share of immigration, while the rest of the U.S. keeps the immigration share at 0.6 percent. Each column represents six different replacement rates, which are increased by 10 percent from no benefit to 50 percent. Thus, there are twenty-four policy combinations which are considered as possible policy mixes. All the values in the table give the average utility resulting from the corresponding policy combinations.

Table 1. Welfare changes of policy mix: Immigration and pension reforms

Share of Immigration	Replacement rate					
	0%	10%	20%	30%	40%	50%
0.0%	-75.48	-74.91	-74.45	-74.30	-74.42	-74.68
0.6%	-75.54	-74.79	-74.11	-73.77	-73.59	-73.60
1.2%	-76.66	-76.21	-75.49	-74.84	-74.66	-74.72
1.8%	-77.39	-76.75	-75.90	-75.43	-75.18	-75.37

Note : Shaded area implies the optimal size of immigration and replacement rate

[14] Average utility W is calculated as $W(a) = \sum_{j=1}^{65} \sum_{a} (\frac{1}{1+\rho})^{j-1} (\prod_{k=1}^{j} s_k) \frac{(C_{i,j}(a))^{1-\gamma}}{1-\gamma}$, where a is end of period asset holdings

According to the table, the welfare changes according to the different combinations of share of immigrations and pension benefits, but not in a monotonic pattern. First, in case of the pension reforms, the welfare gain rises proportionally, increasing as the replacement rate changes from zero percent to 40 percent. Beyond this point, an increase in the replacement rate, on the contrary, lowers the welfare. To explain this irregular welfare changes, we need to consider both welfare benefits and costs associated with changes in replacement rate. First, the welfare benefits results mainly from the efficient consumption allocation associated with an increase in replacement rate. That is, mortality risk motivates individuals to discount the future consumption more heavily and to consume less in old age than they otherwise would. Thus, in the absence of private annuity market against lifetime uncertainty, the age-consumption profile diverges from a more efficient allocation which shows a relatively smoother consumption profile. In addition, positive unintended bequests by early death also cause inefficient consumption allocation in the absence of an annuity market. That is, the absence of annuity market causes inefficient consumption allocation under lifetime uncertainty. However, the social security pension program partially substitutes for missing annuity markets acting as a public insurance against uncertain lifetimes. With a financial support of pension program, each individual could allocate the lifetime consumption closer to a more desirable age-consumption profile by increasing the consumption in old age which would otherwise fall far below the optimal level. According to the simulation results, the average consumption of retirees increases 18 percent as the replacement rate shifts from zero percent to 50 percent. This beneficial feature of the pension program explains the reason why the generous pension benefit increases the welfare. Conversely speaking, this feature explains why the welfare changes for the worse with the pension reforms.

On the other hand, an increase in the replacement rate also generates welfare costs. Most working age populations reduce their consumption corresponding to the higher tax rate required for supporting the generous pension benefit. Especially, in this specification, those in the 20s age group give up about 20 percent of their consumption when the replacement rate increases from zero to 50 percent. As a result, an increase in replacement rate lowers the aggregate consumption, and this loss partially offsets the insurance benefits of pension program associated with a more efficient consumption allocation. Another important cost of the social security pension program arises from the existence of borrowing constraints. The higher the replacement rate is, the more incomes are redistributed away from the young generations who face liquidity constraints. Once an individual is subject to a binding liquidity constraint, the equilibrium age-consumption cannot be allocated according to the optimal rule. Thus, an individual's consumption further diverges from the desirable age-consumption profile; this negative welfare impact becomes stronger as the pension benefit becomes more generous. Beyond a replacement rate of between 40 percent and 50 percent, both negative welfare costs eventually outweigh the insurance benefits of the pension system, meaning that the optimality of the pension system occurs at a replacement around 40 percent. However, this optimality condition, which is 40 percent of replacement rate, occurs under immigration policy. Without immigration, it drops to 30 percent because without financial support from immigrants, the social security tax rate substantially increases; hence, more generous pension benefit cause higher welfare costs.[15]

Next, the level of welfare associated with immigration also changes according to the different size of immigration. According to the simulation, the optimal level of immigration occurs at the

[15] Imrohoroglu et al. (1995) evaluate the welfare changes according to alternative pension reforms without considering immigration, and report that the maximum benefit of social security occurs at a replacement rate of 30 percent.

share of immigrants in the neighborhood of 0.6 percent. However, beyond this point, like pension reforms, an increase in immigrants generates welfare cost. Now, it is a question as to why the optimal share of immigration does not occur at zero percent, since immigration distorts the local labor market by reducing the wage. The main reason is because immigrants significantly contribute to reducing the distorting payroll tax which makes it hard to allocate the consumption following the optimal conditions. However, this benefit does not imply that an increase in the share of immigrants necessarily results in more welfare benefits. The main reason for this prediction is attributable to the difference of the immigration policies between federal and local government. Increasing the immigration share from zero percent to 0.6 percent, both regions admit the same share of immigrants, so that the social security tax rate is substantially lowered since it is determined at the national level. Beyond the 0.6 percent, only Chicago region attracts more new immigrants. However, the additional number of new immigrants admitted in Chicago region is not sufficient to lower the tax rate, meaning that the increase in the number of local immigrants beyond the national average does not generate the additional benefits arising from cuts in the national social security tax rate. Instead, the welfare cost arising from smaller wage becomes larger as more local immigrants are newly admitted. Of course, there still exits the welfare benefits for local residents because more immigrants generally stimulate higher economic growth. However, as long as the share of local immigration is higher than national average, this benefit is necessarily dominated by welfare cost.

As a result, the optimal combination found in this model occurs at 0.6 percent of immigration share and 40 percent of replacement rate. This result importantly implies that the larger immigrants and more generous pension benefit do not necessarily result in more desirable policy

combinations. Especially, local government should pay attention to keep the volume of local immigrants at about the national average.

Another interesting finding is closely related to the dependence of immigration policy on pension reforms. That is, welfare benefit of immigration changes according to the size of pension reforms. Especially, welfare effect of immigration is totally reversed once the pension reforms are completed. In this economy, immigration leads to the welfare benefit only when the share of immigration shifts from zero percent to 0.6 percent. However, the size of welfare benefit from this change becomes smaller as the pension system is reformed toward a lower benefit. For the case with no public pension system with zero replacement rates, immigration only carries the welfare cost which monotonically increases as the number of immigrants rises. As mentioned earlier, the reason for this result is that pension reforms toward the smaller benefit unambiguously lowers the tax burden, which reduces the potential benefit of immigration. Thus, once the social security pension program is entirely abolished, then the welfare benefit from the immigration might almost disappear.

5. Conclusions and Future Work

This paper has analyzed the dynamic effects of immigration on the economies, whose national effects have been already intensively analyzed before this study. This paper focused on filling the void of analyses at the regional level. To generate the simulated results, a two-region dynamic general equilibrium model has been used, incorporating an overlapping generations structure with individual heterogeneity and uncertainty. Considering the demographic features and expected dramatic changes in local population structure, the Chicago region is chosen as the

reference region. To capture the distinctive socio-economic impacts arising from regional demographic changes, most of the simulations consider the comprehensive impacts on economic growth, income (asset) distribution, and welfare benefits. The main findings are as follows.

First, in the case of immigration, uneven changes of capital and labor supply over the transition periods generate time variant dynamic results. Over the whole transition period, favorable immigration policy significantly contributes to increasing economic growth in the Chicago region. However, until the newly admitted immigrants acquire higher labor productivity, the per capita GRP decreases as the number of immigrants increases. In addition, the initial benefit for the social security program is reversed around 2050s, when the first immigrants start to retire. Immigration also turns out to distort the income distribution because it decreases earnings of the poorer population by reducing wages. In particular, more immigrants in the region than national average only increases the income disparity without reducing the social security tax burden.

Secondly, according to the simulation results for finding optimal policy combinations, the larger immigrants and more generous pension benefit do not necessarily result in more desirable results. As an optimal policy mix, this model suggests that the regional welfare is maximized when the local government admits immigrants up to the national average under conditions where the pension program adopts a 40 percent replacement rate. Also, pension reforms toward the small benefit turns out to reduce the potential benefit of local immigration.

It is hoped the results of this study would present valuable policy implications to local and federal governments to assist them in preparing for the economic and social consequences of future demographic changes. This work should be critically important to those regional states that implement favorable immigration policies to attract more immigrants by providing

incentives for the immigrants, such as medical support. While the case study focused on Chicago and the Rest of the US (as the second region), the methodology is sufficiently portable be applicable to other regions. Further research future work could extend this structure to a multiregional context. In addition, the model needs to be extended to evaluate the explicit dynamic analysis of the intersectoral reallocation of resources induced by demographic changes.

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