Immigration, Aging, and the Regional Economy

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Abstract

*Using a two-region computable general equilibrium model (*Chicago *and* Rest of the United States*) integrated with an Overlapping Generations model, this analysis explores the implications of various indicators for changes in the level of immigration in Chicago. Initially, and not surprisingly, wages fall as a result of increased immigration. This finding is consistent with an equilibrium view of a market receiving a supply shock and a fall in the capital/labor ratio; but after 2040, the effects appear to be reversed. One reason for this reversal can be traced to the retirement of the first wave of immigrants, but more important, increasing numbers of immigrants will provide contributions to taxes that will reduce the social security tax burden and thus increase the after-tax income of native workers. Over time, the model assumes that immigrants and their offspring begin to accumulate skills so that they become undifferentiable from the native population. In terms of regional macroeconomic impacts, immigration would appear to reverse a projected decline in gross regional product (GRP) that would occur essentially as a result of an aging population with no stimulus provided by immigration. In per capita GRP terms, however, the positive effects occur only after the immigrants (cumulatively) acquire skills to elevate their productivity levels. The Chicago region, under an asymmetric immigration policy (Chicago gains more immigrants as a percentage of its base population than the United States as a whole), actually increases its share of gross national domestic product. One might expect that, given these findings, the effect on the social security tax rate would be positive in the sense of either muting increases or actually decreasing the rate. This impact is true until the immigrants start to retire in significant numbers after 2050; this result stems from the fact that, over time, the effects of immigration begin to diminish—a finding that is revealed in the results for the United States as a whole.*

Introduction

Yoon and Hewings (2006) found significant evidence for the presence of nonhomothetic consumption preferences by age and income distribution in the Chicago regional economy.[1] Over a 30-year period, 2000 to 2030, these differences were estimated to generate a statistically different impact on the growth and structure of the region's economy. The econometric input-output model that was used, however, failed to fully explore the implications of changes in migration behavior, especially the significant influx of younger immigrants and the out-migration of retirees. Expanding and elaborating on these findings, Park and Hewings (2007) examined the effect of an aging population, using an Overlapping Generations (OLG) framework in a two-region computable general equilibrium model (Chicago and the Rest of the United States [ROUS]) built on the same database. Absent significant in-migration of largely younger aged people of working age and the continued out-migration of retirees, the Chicago region could expect to experience generally negative effects from an aging population, especially in terms of economic growth. The previous simulation results point out two factors—the labor shortage and insufficient savings—as the main reasons for the economic downturn. In addition, according to the results, the aging could be expected to generate a fiscal burden that would become too onerous for the government to manage, given the current structure of the pension system. Recognizing these concerns, both federal and local governments have been exploring options for handling problems related to an aging population.

Therefore, it is useful to assess the potential benefits and costs of policy reforms and find alternative solutions. At the national level, the existing literature investigating the economic impacts of policy reforms with an aging population has grown explosively since the 1990s and substantially sharpened our understanding of the potential effects. For example, Denton and Spencer (2005) noted that although population growth and technological change were the principal drivers of economic growth, attempting to change population fertility would generate uncertain responses and take several years to have an effect on the economy (through labor force expansion). On the other hand, an increase in immigration of, for example, people aged 20 to 35 would have an immediate effect on the economy. The results of national policy changes may not apply at the regional level, however, because diverse regional effects stemming from variations in economic and demographic structure could exist. In particular, federal government policies that respond to the aging population problem may have different implications across regions. For example, there could be *regional* wage and employment effects of international immigration that are different from those at the *national* level. These differences stem, in part, from differential rates of interregional migration that may respond (with some lag) to changes in regional labor market conditions (crowding out by immigrants in one region perhaps leading to depressed wages or enhanced wages in others due to relative labor shortages).

This article explores the effects of changes in immigration policies; the model assumes that the immigration policies between local and federal government are differentiated. This differentiation occurs because of quotas, visa requirements, or guest worker programs (regions have no power to act in these domains); it is more in terms of a region's ability to compete more effectively for the

[1] The Chicago region is the metropolitan statistical area comprising Cook, DuPage, Kane, Lake, McHenry, and Will Counties.

pool of in-migrants. Focusing on the Chicago region, this analysis assumes that the local government implements a more favorable set of incentives to attract more immigrants than other regions do, with the result that the inflows, as a percentage of the base population, may be higher than those recorded at the national level. These incentives might include housing subsidies, enhanced social and healthcare programs, proactive recruiting policies (through public-private partnerships), and general enhancement of the current process of channelization of immigrant flows. Regions with high existing levels of immigrants have a higher probability to compete more effectively for new immigrants using family and community ties to provide information to potential in-migrants from their home countries. Roseman (1971) identified this process in examining the immigration flows in the United States from the South to specific Midwest cities in an earlier period; it is likely that such processes characterize international immigration flows to the United States. Of course, another potential source of increased regional immigration could result from the increased attraction of migrants from other regions in the United States. As Plane (1992) and Plane and Heins (2003) have demonstrated, striking age effects are evident in the characterization of these flows. Considering both in- and out-migrants, over the period 1985 to 1990, Illinois reported a net loss of 70,000 retirees aged 60 and older, ranking the state as second largest among all the states. Further, the Chicago area accounts for more than 80 percent of the older migrants who leave Illinois; for example, the Chicago region loses about 0.9 percent of its older population, or about 12,000 retirees, every year.

The next section of this article provides a brief review of the model and summarizes previous analyses of the effects of aging alone on the Chicago economy. The section after that considers some plausible scenarios for the regional effects of different volumes of in-migration, and the following section reports the results. The article concludes with a summary evaluation.

The Model[2]

The model is presented in more detail in Park and Hewings (2007); the critical components are reviewed here in terms of the immigration impact analysis. The model is represented by a two-region dynamic general equilibrium model with an OLG framework, drawing on Auerbach and Kotlikoff (1987). Individual earnings heterogeneity, demographic transitions, and the existence of a social security system are assumed. There are two major differences to the prior OLG framework, the first being the specification in a two-region context (Chicago and the ROUS), in which each region is interlinked with the other by migration, trade, and the social security system. Labor is assumed to be partially mobile in domestic regions, while immobile internationally (immigrants enter but no consideration of international out-migration is provided), taking into account people's preference for staying in the region where they originally reside.[3] 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 the

[2] This section draws on Park and Hewings (2007).

[3] 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.

labor market. Capital, however, is assumed to be immobile interregionally.[4] This immobility results in the return on capital being different across the regions. The second difference is that the model features age-specific mortality and borrowing constraints, which are critically important to generate realistic implications of the effects of demographic changes.

Households (this model has a one-to-one mapping between individual agents and households) maximize their utility by choosing a profile of consumption over the life cycle and firms demand factors of production 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. A nesting structure is assumed for 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, thus ensuring that consumers demand goods produced in both regions. The hierarchy in the 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 decisionmaking in the nesting structure. After optimal conditions governing the aggregate consumption levels are established, the second step is to allocate these expenditure levels among differentiated goods in terms of geographic origin—that is, goods produced in Chicago versus goods from the ROUS. 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 this elasticity.

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 the dynamic processes that describe the path of consumption and savings behavior of each age cohort over time. Three types of agents are in each region: (1) households, (2) firms, and (3) 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 feedback among these agents, according to demographic changes and relevant 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 because, under this assumption, less than 3 percent of the U.S. population is not considered.[5] The individual agent enters the labor market at age 21 and retires mandatorily at age 65. Because all the individuals up to age 20 are considered not to perform economic activities, reflecting that their parents support them, this model deals only with the individual agents age 21 and older. Lifetime uncertainty is considered in this model; that is, each individual faces a different probability of death in every period, which becomes higher as he or

[4] The treatment of capital mobility is important when assessing the regional investment policies.

[5] Evidence indicates that the migration behavior of retirees is not homothetic regarding age, with out-migration in the early 60s age group accompanied by significant return migration in the 70s and 80s age groups. Frey (2007) recently estimated that many people aged 75 and older moved from the South to the Midwest between 2000 and 2005.

she ages. Therefore, in every period, some fraction of people dies earlier than at age 85 and leaves accidental bequests since annuity markets are assumed to be missing.[6] 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 a higher payroll tax on younger generations that face binding borrowing constraints.

Individuals are endowed with one unit of time and supply the labor inelastically. Because 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; wage income depends on the individual's productivity, which is assumed to be identical across regions. Wage income might differ across regions, however, 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 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 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.

The working population in the model age comprises the groups from 1 to 44 (ages 21 to 65) and is assumed to be partially mobile across domestic regions. The net out-migration of labor is determined by the wage elasticity of labor migration, as seen in equation (1):

$$M_t^w = POP_t^w\left(1-\frac{w_t^{CHI}}{w_t^{ROUS}}\right)^{\eta} \tag{1}$$

where M_t^w denotes the number of net out-migration of labor at time t, POP_t^w is the aggregate stock of labor given at the beginning of time t, w_t^{CHI} and w_t^{ROUS} are the wage rates in Chicago and the ROUS, and η refers to the wage elasticity of labor migration.

In equation (2), the stock of effective labor, L_e, is defined as the number of net workers $\left(N_t^w\right)$ times their corresponding productivity level (e_j) as follows:

$$\begin{aligned} L_{e,t} &= \sum_{j=1}^{44}\left(POP_{j,t}^w - M_{j,t}^w\right)e_j \\ &= \sum_{j=1}^{44} N_{j,t}^w \cdot e_j \end{aligned} \tag{2}$$

In equation (3), retirees 65 and older are assumed to migrate from one region to another region with an exogenously given rate, ε, where M_t^R and POP_t^R are the number of retiree migrants and total retirees population at time t, respectively:

$$M_t^R = \varepsilon \cdot POP_t^R \tag{3}$$

The appendix provides more details of the model structure.

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

Increasing Immigrants

The issues surrounding international immigration have become some of the most debated topics, because international immigration has both positive and negative effects on the host economy. One of the biggest costs that immigration might create would be through adverse effects on the local labor market by crowding out native workers; increased immigration could reduce wages and exhaust employment opportunities for native workers, especially for those who are young and have low skills. Also, high-income disparities could be generated due to the large decline in the income of low-skilled workers. On the other hand, immigration fundamentally changes the age structure and may be very helpful in contributing to a solution to the demographic imbalance caused by an aging population. Also, one of the most common arguments in favor of immigration is that it will significantly alleviate the potential insolvency problem of the social security program, because immigrants pay social security tax and usually have no parents in the country who are currently drawing on the system. Of course, this argument assumes that the immigrants participate in the formal economy (whether they are legal or not) and thus contribute through direct and indirect taxes.

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 the fifth leading immigrant-receiving state. It has admitted nearly 0.4 million legal immigrants in the past decade, an average of 40,000 immigrants a year. The cumulative total of legal immigrants in Illinois between 1965 and 2002 was estimated to be 1.3 million. In addition, according to the U.S. Citizenship and Immigration Services (formerly the Immigration and Naturalization Service), more than 0.4 million illegal immigrants reside in Illinois; most of them are concentrated in Chicago region. Since 1993, more than three-fifths (64.7 percent) of all immigrants have come from China, India, Mexico, the Philippines, Poland, and the former Soviet Union. Mexico alone has accounted for nearly one-fourth of all new immigrants (24.8 percent). This influx of new immigrants will account for a much more significant share of Chicago's population in the next decade; currently, the Latino population of Chicago slightly exceeds that of the African-American population and is growing more rapidly as a result of higher rates of natural increase, as well as through in-migration (including both interregional and international contributions).

Simulations for impact analysis were conducted using the following three scenarios, which are differentiated by the number of immigrants for both regions, Chicago and the ROUS. 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 entering the Chicago region between 1993 through 2002. Scenario 2, in contrast to the first scenario, assumes that only the Chicago region admits more immigrants, while the rest of the United States fixes the share of immigrants at 0.6 percent. That is, in scenario 2, the proportion of newly admitted immigrants into the Chicago region is adjusted to 1.2 percent of the population, or about 0.1 million per year.[7] Scenario 3 assumes that the local government for Chicago adopts more favorable immigration

[7] Storesletten (2000) found that the minimum number of immigrants required to balance the fiscal budget is 1.08 percent of the population in the United States.

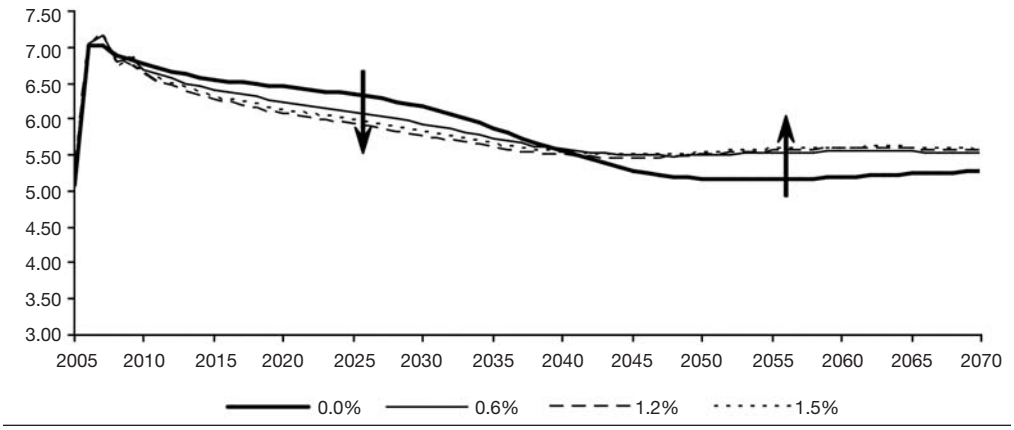
attraction policies, whereby the number of annual immigrants entering the Chicago region increases to 1.5 percent of its population, or about 0.12 million a year. According to these scenarios, the dependency ratio (the percentage of the dependent old-age populations, aged ≥65, to the population in the working age groups, (aged 15 to 64) in the Chicago region is expected to be substantially reduced over the next several decades. For example, without immigration, the model projects a significant increase in the dependency ratio from 19 to 32 percent over the next 30 years, whereas in scenario 3, new immigrants contribute to dropping the dependency ratio in the 2030s to 19 percent, about the same level (in 2005) as before the effects of an aging population. Taking into account the characteristics of immigrants that are assumed to be younger and lower skilled than the resident population, newly admitted immigrants are assumed to be equally distributed between the ages of 21 and 35, with an average productivity of about 60 percent of the peak at 47 years of age. The baseline scenario, used to compare its results with scenarios 1 through 3, assumes an aging population with no immigration.

Results

Exhibits 1 and 2 provide plots of the transitional profiles for the capital/labor ratio and wages, respectively. Initially, the inflow of young immigrants lowers the capital/labor ratio, and that, in turn, contributes to decreases in wages. After the initial period, however, the fall in the capital/labor ratio corresponding to accumulating immigrants begins to decrease and ceases its downward trend around 2040, about 5 years earlier than the baseline scenario (no immigration). After 2040, the wages under favorable immigration remain higher than the baseline scenario. This result is somewhat counterintuitive because large immigration should be expected to exert a strong downward effect on wages. One possible reason for this result is because the first immigrants start to retire in the early 2040s, resulting in an increase in the capital/labor ratio. For this result to happen, however, two more important factors are at work. The first factor is that the more immigrants that are admitted, the more native workers can save, because immigrants will significantly reduce the social security tax burden (by increasing the after-tax income of native workers). Second, at the time

Exhibit 1

Capital/Labor Ratio (Chicago)



of immigration, it is assumed that the capital does not flow into the host country with immigration, but once immigrants start to work and acquire the higher levels of productivity, they can accumulate more savings, thereby increasing aggregate capital stock. This is a critical assumption, especially as it pertains to the second and succeeding generations of offspring from the original immigrants.

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. Exhibit 3 shows how the regional output would be changed by immigration streams over time. According to the simulation results, an increase in immigrants appears to have more positive effects 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 the

Exhibit 2

Wages (Chicago)

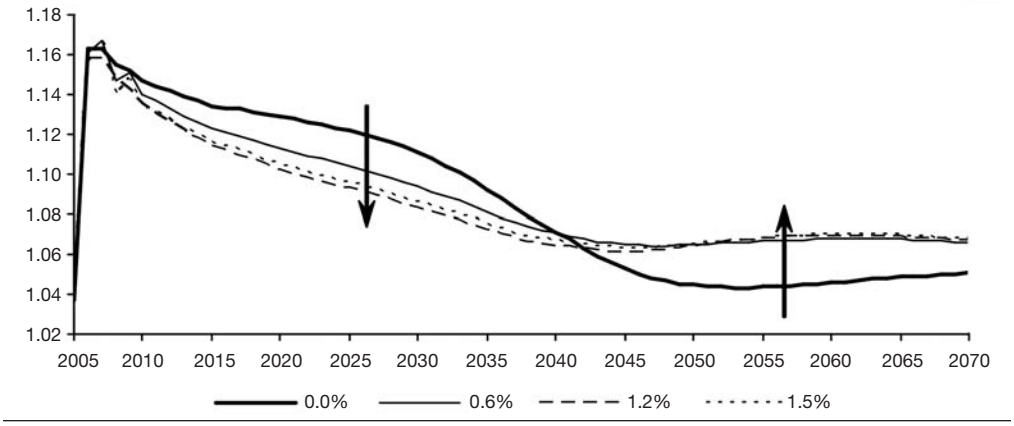
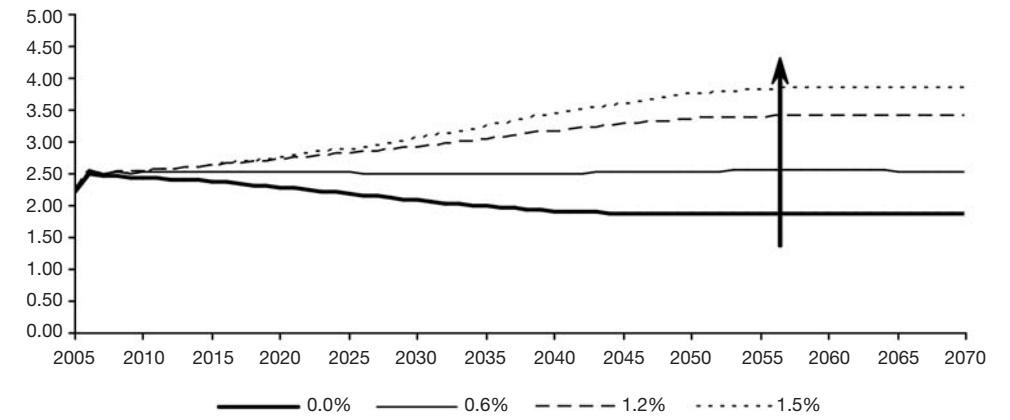


Exhibit 3

GRP (Chicago)

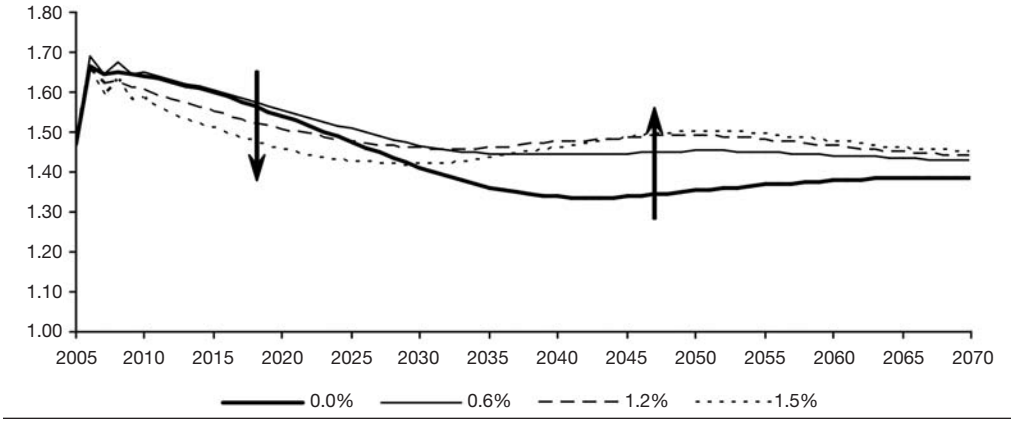


GRP = gross regional product.

effects of an aging population. This result can be fully expected because immigration provides a positive labor supply shock to the local economy. The transitional profile of per capita gross regional product (GRP), however, is not similar to that of aggregate GRP, as shown in exhibit 4. During the initial period, relatively larger immigration, in scenarios 2 and 3, keeps the per capita GRP remaining at a lower level than that of the baseline scenario because the immigration increases (by assumption) only the supply of low-skilled workers. After the 2030s, however, when the first immigrants really begin to acquire higher levels of productivity, per capita GRP assumes an upward trend and grows faster than the baseline scenario. This positive trend also substantially contributes to reducing the decline of per capita GRP under an aging population. For example, between 2005 and 2070, negative 5.5 percent of per capita GRP growth under an aging population is reduced to a range of values from negative 2.6 percent in scenario 1 to negative 1.9 and negative 1.2 percent in scenarios 2 and 3, respectively. Exhibit 5 reveals that the GRP share of the GNP for the Chicago

Exhibit 4

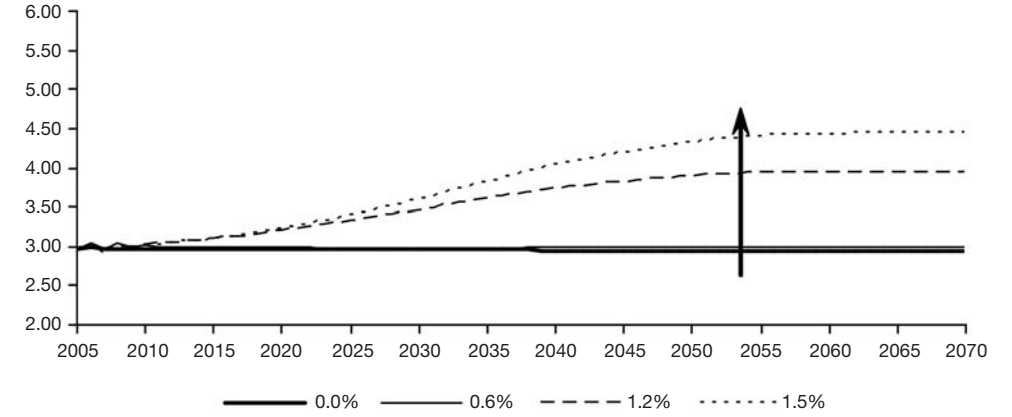
Per Capital GRP (Chicago)



GRP = gross regional product.

Exhibit 5

GRP Share (Chicago)



GRP = gross regional product.

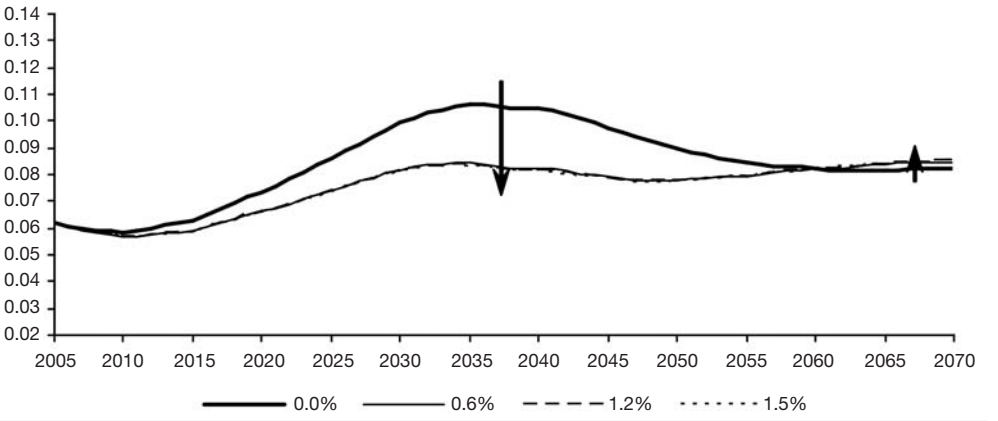
region noticeably increases from 3.0 percent to around 3.5~4.0 percent in scenarios 2 and 3, because both scenarios assume a relatively higher share of immigrants are admitted only in the Chicago region.

Exhibit 6 shows the projected effect on the social security tax rate. Not surprisingly, a larger number of working-age immigrants appears to have a significant downward effect on the social security tax rate. Because of this downward pressure, in 2050 the social security tax rate is projected to return to the level established before the effects of an aging population. This benefit is one of the most significant to be generated from immigration. On closer look, however, the benefit for the 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 reveals that, in the longer run, immigration could generate a different effect; as immigrants age, like everyone else, a sustained policy of immigration has little long-run effect on the age structure of the population, and thus its benefit declines. Another important policy implication, especially for local governments, arises from the different stance on immigration between Federal and local governments. In the case of scenarios 2 and 3, only the Chicago local government optimistically attracts more immigrants than does the national average. The social security tax rate changes insignificantly, however, because the additional working-age immigrants in Chicago region are not of a significant size to decrease the tax rate, which is influenced by changes in the national population. Therefore, locally increased immigration may only hurt the local labor market without generating additional tax benefits. This point is important; local autonomy in the case of a small region has limited effect on national policy that, in turn, could affect the outcome in Chicago.

Exhibits 7 and 8 present the effects of immigration on both income and asset distribution, respectively. Immigration has a negative effect on equality in terms of income distribution; that is, the income Gini coefficient becomes larger as more immigrants are admitted. This increase in inequality can be explained by the following two reasons. First, younger, lower income groups substantially rely on labor income, while middle-aged populations earn larger incomes from both asset holdings and labor earnings. Thus, the younger populations become relatively poorer as more

Exhibit 6

Social Security Tax Rate



immigrants decrease wage income, whereas richer, middle-aged populations are not much affected by immigration because they earn larger capital income as a result of the increases in the interest rate. The second reason is closely related to the change in the demographic structure associated with immigration. Before the first immigrants start to retire around the 2040s, the share of the population with larger income increases relatively faster than the younger and older poor populations because more immigrants acquire higher skills and become richer. This structural change in population increases the aggregate income gap between the richer middle-aged population and the poorer young and old populations. After the 2040s, however, because wages start to increase and immigrants starts to retire, the Gini coefficients in all immigration scenarios start to fall. In contrast to the income distribution effect, immigration improves the equality of asset distribution until the mid 2030s; that is, the asset Gini coefficient falls. The effect of immigration on asset distribution, however, is reversed during the subsequent period. Basically, immigration has an upward pressure

Exhibit 7

Income Gini Coefficient (Chicago)

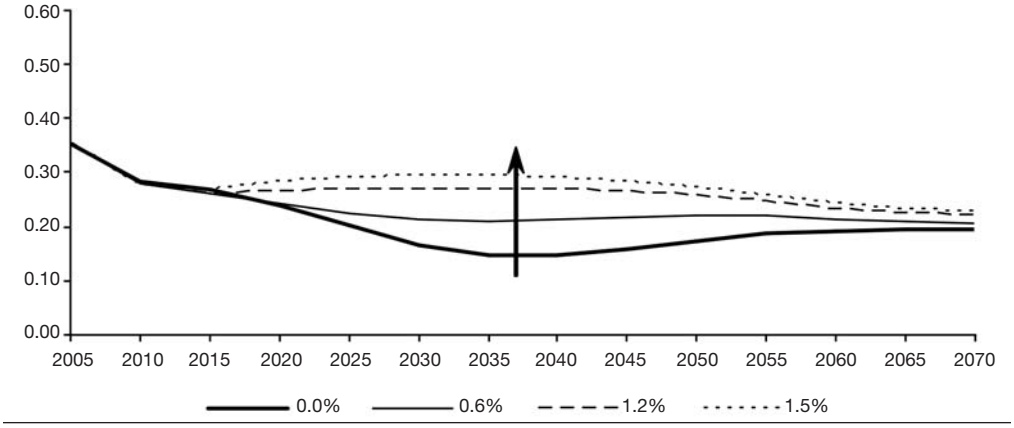
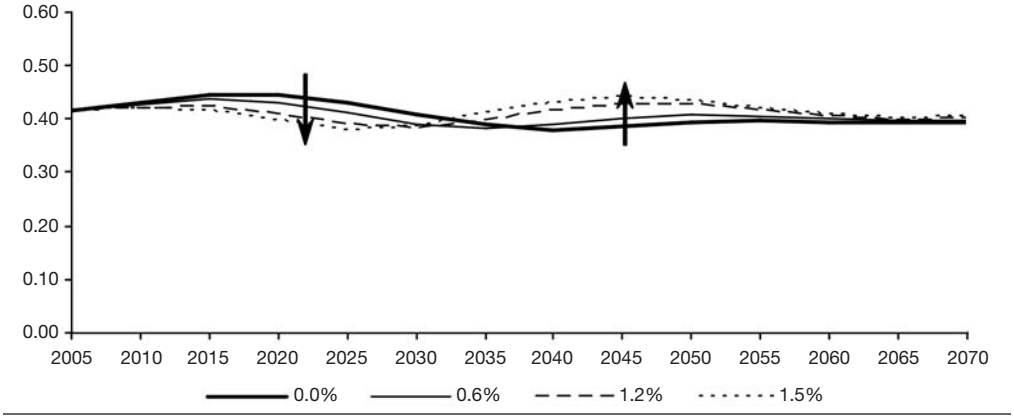


Exhibit 8

Asset Gini Coefficient (Chicago)

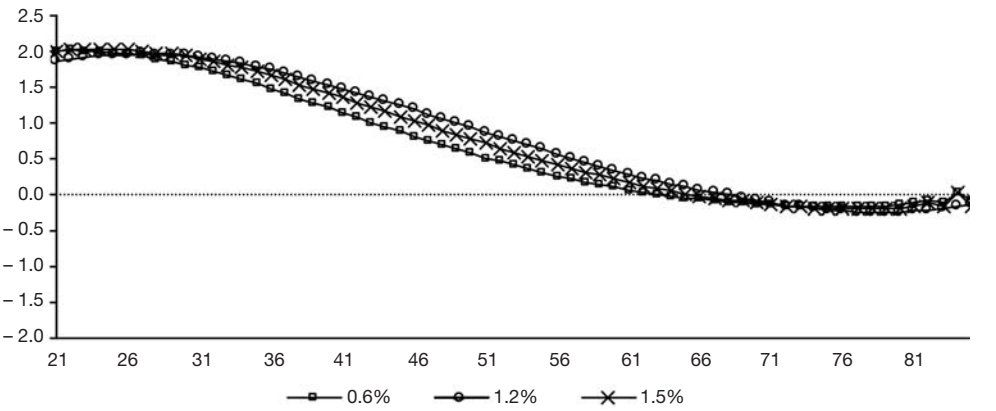


on the asset Gini coefficient, because it increases the asset holdings of the wealthiest group without significant changes in asset holdings of younger generations that face liquidity constraints. In the initial period, however, the increasing number of younger populations associated with new immigrants drives the asset Gini coefficient down, reflecting the reduced gap of the aggregate asset between the middle-aged, wealthy population and the younger, poor population.

Exhibit 9 shows how the welfare effects of immigration vary over the transition periods.[8] The welfare benefit is measured by a consumption equivalent variation (EV),[9] which computes the consumption change required to keep the expected utility in the initial condition equal to that achieved in the new condition under immigration policies. Given the form of the utility function, a positive (negative) EV implies that the 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 big 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 outcome is good news for current young generations. Unlike the assumption of this model, however, 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.

Exhibit 9

Equivalent Variations (Chicago)



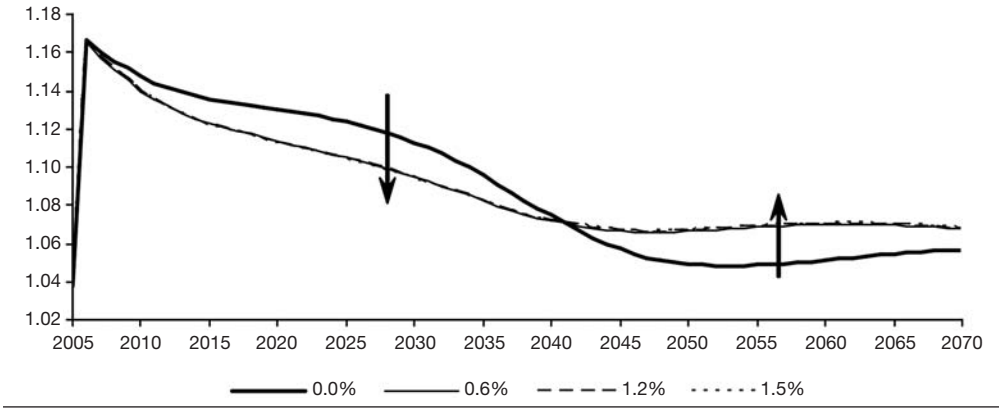
[8] Welfare effects of the policy reforms between steady states, which does not consider the welfare changes during the transition periods, are reported in the policy mix.

[9] 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 last five exhibits, exhibits 10 through 14, show how the increase in the number of immigrants affects the economy of the ROUS. As in the Chicago region, the immigration fundamentally changes the age structure of the ROUS and is generally helpful in solving the economic growth problems of an aging population. It appears, however, that the immigration policy of the Chicago region has only a marginal effect on the economic growth and welfare of the ROUS. Of course, this result is due to the relatively modest size of the Chicago region compared to the ROUS. Thus, the reverse is not true as shown in scenario 1.

Exhibit 10

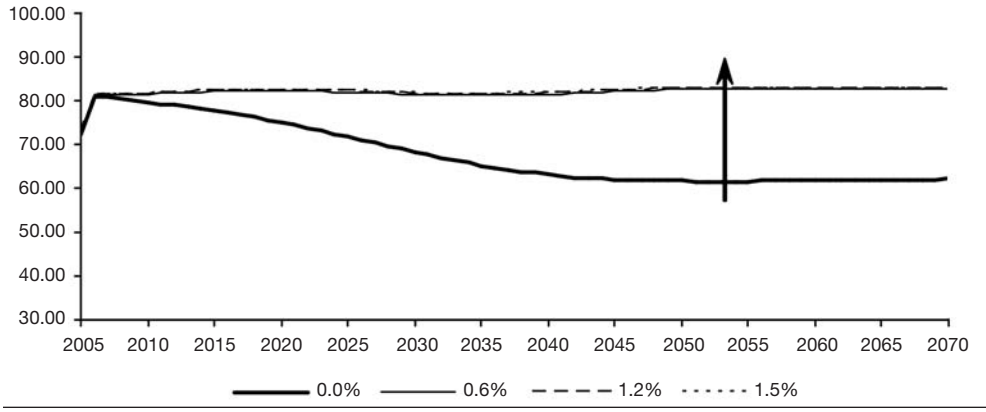
Wages (ROUS)



ROUS = Rest of the United States.

Exhibit 11

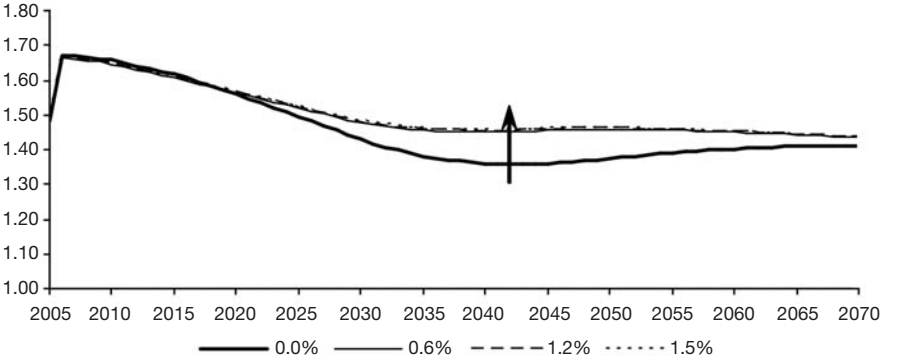
GRP (ROUS)



GRP = gross regional product. ROUS = Rest of the United States.

Exhibit 12

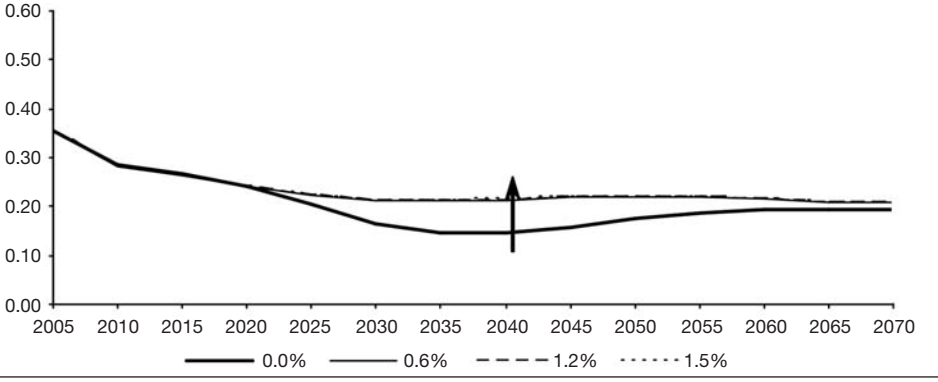
Per Capita GRP (ROUS)



GRP = gross regional product. ROUS = Rest of the United States.

Exhibit 13

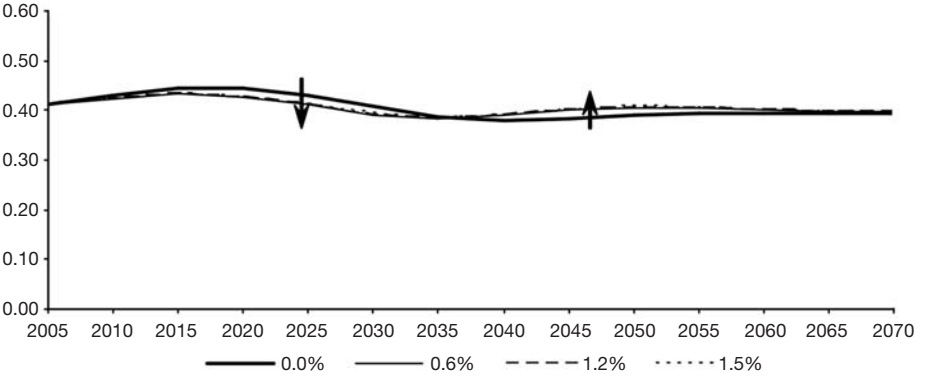
Income Gini Coefficient (ROUS)



ROUS = Rest of the United States.

Exhibit 14

Asset Gini Coefficient (ROUS)



ROUS = Rest of the United States.

Evaluation and Conclusions

As with any model, the interpretation of the results is rooted in the reasonableness of the assumptions. For an economy that is small relative to the nation (although still large in absolute terms), the outcomes in terms of enhanced flows of immigrants are variable. The results provide insights into the complexity of the immigration debate and why it is so difficult to navigate a policy outcome that is consistent in the sense that it provides either continuously positive or negative outcomes over time. Consider the effects on wages; initially, and, not surprisingly, wages fall as a result of increased immigration. This finding is consistent with an equilibrium view of a market receiving a supply shock and a fall in the capital/labor ratio; but after 2040, the effects appear to be reversed. One reason for this fall can be traced to the retirement of the first wave of immigrants, but, more importantly, increasing numbers of immigrants will provide contributions to taxes that will reduce the social security tax burden and thus increase the after-tax income of native workers. Over time, the model assumes that immigrants and their offspring begin to accumulate skills in such a way that they become undifferentiable from the native population. In terms of regional macroeconomic effects, immigration would appear to reverse a projected decline in gross regional product that would occur essentially as a result of an aging population with no stimulus provided by immigration. In per capita GRP terms, however, the positive effects occur only after the immigrants (cumulatively) acquire skills to elevate their productivity levels. The Chicago region, under an asymmetric immigration policy (Chicago gains more immigrants as a percentage of its base population than the United States as a whole), actually increases its share of gross domestic product.

One might expect that, given these findings, the effect on the social security tax rate would be "positive" in the sense of either muting increases or actually decreasing the rate. This positive effect is true until the immigrants start to retire in significant numbers after 2050; this result stems from the fact that, over time, the effects of immigration begin to diminish—a finding that is revealed in the results for the United States as a whole.

In this article, it is assumed that consumers are forward looking and have the capacity to adjust their consumption to anticipate needs in retirement; however, little has been said about the optimal policy strategy for a region such as Chicago. Does it make sense to adopt a proactive immigration policy? Given the findings, is there some imperative to increase the immigration rate over time or is there some longrun optimal level? This part of the analysis is incomplete; further, it would be unrealistic to explore the issue without consideration of the expected structural transformation of the economy. Beyond 2050, confidence in forecasts must be more heavily depreciated, but they cannot be ignored because there appears to be an important turning point in the welfare implications during the 2030–50 period. Clearly, this area is one in which more intensive analytical fine-tuning needs to be accomplished; what is not in dispute, however, is the importance of skill acquisition and the enhancement of productivity levels in the immigrant populations and their offspring.

Appendix: Model Specification and Data Calibration

The model is described in more detail in Park and Hewings (2007). This appendix summarizes the more important features of the structure.

Household Sector

Each individual makes lifetime decisions about consumption and savings at the beginning of his or her adult life, leaving no voluntary bequests and receiving no inheritances. Because each agent is represented as forward looking and having perfect foresight, the evolution of consumption and savings depends on all future interest rates and after-tax wages.

Representative agents of each age cohort maximize a time-separable expected lifetime utility function, U, that depends on streams of aggregate consumption goods, C. Mortality risk is represented by the conditional probability, s. $\prod_{k=1}^{j} s_k$ is then the unconditional probability of being alive at age k, as shown in equation (4):

$$U_i = \sum_{j=1}^{65} \left(\frac{1}{1+\rho}\right)^{j-1} \left[\prod_{k=1}^{j} s_k\right] \frac{(C_{i,j})^{1-\gamma}}{1-\gamma} \tag{4}$$

where $C_{i,j}$ is the aggregate consumption of an individual of age j in i_{th} generation, ρ is the subjective discount rate, and γ is the inverse of the intertemporal elasticity of substitution. Thus, the effective discount rate is expressed as $\left(\frac{1}{1+\rho}\right)^{j-1} \prod_{k=1}^{j} s_k \frac{1}{1-\gamma}$, meaning that with mortality risk, the utility of future consumption is more heavily discounted.

At every period, each individual faces the budget constraints described as follows:

$$(1+\tau_c)P^C C_{i,j} + a_{i,j} = (1-\tau_w-\tau_p)w\, e_j + (1+(1-\tau_r)r)a_{i,j-1} + pen_{i,j} + \Phi$$

where $a_{i,j}$ is the asset of generation i at age j; τ_w, τ_c, and τ_r are tax rates on labor income, consumption, and capital income, respectively; τ_p is the social security tax rate (that is, pension contribution rate); w is the wage; r is the interest rate; and P^C is the price of aggregate consumption good. $pen_{i,j}$ stands for the pension benefit of generation i at age j, and Φ is the transfer from accidental bequests. An individual's labor productivity is assumed to be an exogenous function of his or her age.

This productivity difference by age is captured by e_j, which changes with age j in a hump-shape way (Miles, 1999). For simplicity, productivity age profile, e_j, is constant in terms of time and region, as shown in equation (5):

$$e_j = \lambda_1 + \lambda_2 j - \lambda_3 j^2 \tag{5}$$

With the maximization procedure, the following standard first-order conditions can be derived, concerning consumption per period. Equation (6) implies that the marginal rate of substitution between consuming now and consuming later equals the relative price of consuming later instead of now:

$$\begin{aligned} C_{i,j} &= \left(\frac{1+r_t}{1+\rho}\right)^{\frac{1}{\gamma}} \left\{\frac{P^C_{t-1}(1+\tau_{c,t-1})}{P^C_t(1+\tau_{c,t})}\right\}^{\frac{1}{\gamma}} C_{i,j-1} \\ C^A_t &= \sum_{j=1}^{65} N_{65-j+1,t} C_{t-j+1,j} \end{aligned} \tag{6}$$

where C_t^A is the aggregate consumption at time t, and $N_{j,t}$ measures the number of people in age cohort j at time t.

The wealth accumulation equation—equation (7)—can be obtained with the maximization procedure, where A_t is the aggregate asset at time t:

$$\begin{aligned} a_{i,j} &= a_{i,j-1}\{1+(1-\tau_{r,t})r_t\}+(1-\tau_{w,t}-\tau_{p,t})w_t e_j + pen_{i,j}-(1+\tau_{c,t})P_t^C C_{i,j}+\Phi_t \\ A_t &= \sum_{j=1}^{65} N_{65-j+1,t}\, a_{t-j+1,j} \end{aligned} \tag{7}$$

After these optimal conditions governing the aggregate consumption levels at each period are established, the next step is to distribute the optimal consumption of its purchases in terms of regional geographic distribution. The representative agent of each age group minimizes total expenditure, with an aggregate level of consumption being a constant elasticity of substitution composite of two regional goods, as shown in equation (8):

$$\min P_s^C C_{i,j,s} = p_s^{HOME} c_{i,j,s}^{HOME} + p_s^{ROUS} c_{i,j,s}^{ROUS} \tag{8}$$

subject to:

$$C_{i,j,s} = \left[(\beta_s)^{(1-\varphi_s)} (c_{i,j,s}^{HOME})^{\varphi_s} + (1-\beta_s)^{(1-\varphi_s)} (c_{i,j,s}^{ROUS})^{\varphi_s} \right]^{1/\varphi_s}$$

where $c_{i,j,s}^{HOME(ROUS)}$ is the consumption of generation i at age group j for a Chicago (HOME) or rest of the United States (ROUS) produced goods at region s, β_s is the consumption share parameter for goods produced in region s, and ϕ_s is the parameter that controls taste for variety. Optimal consumption of the differentiated goods between imports and domestic goods takes the forms shown in equation (9):

$$\begin{aligned} c_{i,j,s}^{HOME} &= \beta_s \left[\frac{P_s^C}{p_s^{HOME}} \right]^{\sigma_s} C_{i,j,s} \\ c_{i,j,s}^{ROUS} &= (1-\beta_s) \left[\frac{P_s^C}{p_s^{ROUS}} \right]^{\sigma_s} C_{i,j,s} \end{aligned} \tag{9}$$

where σ_s is the Armington elasticity of substitution for consumption in regions s between homemade goods and imported goods[10]. Equation 9 implies that the demand by an individual of region s for a good produced in each region is the function of the price of that good relative to the price of aggregate goods and of the quantity of aggregate goods the individual wants to buy.

Equation (10) shows that combining equation (9) with equation (8) yields the aggregate price (P_s):

$$P_s = \left\{ \beta_s \left[p_s^{HOME} \right]^{1-\sigma_s} + (1-\beta_s) \left[p_s^{ROUS} \right]^{1-\sigma_s} \right\}^{1/(1-\sigma_s)} \tag{10}$$

[10] σ is equal to $1/(1-\varphi)$. Thus, as long as ϕ is sufficiently less than 1, which implies σ is finite, consumers regard each good produced by different origin as an imperfect substitute and prefer variety.

Production Sector

In each region, a single representative firm specializes in the production of a unique regional good. Production in every period takes place with a constant return to scale of a Cobb-Douglas production technology, using capital stock installed at the beginning of the period in the region and the full regional labor force, as shown in equation (11):

$$Y_t = AK_t^{\alpha} L_{e,t}^{1-\alpha} \tag{11}$$

where Y is the output; A and α stand for scale parameter and capital income share, respectively; and K and L_e represent the capital stock and effective labor force, respectively.

The current cash flow of the firm π_t is determined by equation (12):

$$\pi_t = P_t^C Y_t - w_t L_t - P_t^C I_t \tag{12}$$

where $I_t = K_t + (1-\delta)K_{t-1}$ is the investment, and δ stands for depreciation rate of capital. The firm maximizes its value, which is expressed as future cash flow discounted by gross interest rate R, as shown in equation (13):

$$\max \sum_{t=0}^{\infty} \left(\prod_{s=0}^{t} \frac{1}{R_t}\right) \pi_t \tag{13}$$

The first order conditions to this problem yield the factor demand conditions, as shown in equation (14), equation (15), and equation (16):

$$\frac{re_t}{P_t^C} = \alpha A K_t^{\alpha-1} L_{e,t}^{1-\alpha} \tag{14}$$

$$\frac{w_t}{P_t^C} = (1-\alpha) A K_t^{\alpha} L_{e,t}^{-\alpha} \tag{15}$$

$$R_{t+1} = (re_{t+1} + (1-\delta)) \frac{P_{t+1}^C}{P_t^C} \tag{16}$$

where re is rental return of capital. Equation (16) implies that the unique gross interest rate is increased by rental return of capital and capital gains.

Government Sector (Generic Government)

The role of the government in this economy is simply to levy the taxes and administer the social security programs. The government has three types of taxes: wage income tax, consumption tax, and capital income tax. Since this economy ignores the public debt, the government balances the budget constraint, spending tax revenues without issuing government bonds. The government decides tax rates according to budget constraints to balance for each period. The government budget constraint is defined as shown in equation (17):

$$\sum_{j=1}^{65} N_{j,t} (\tau_{w,t} w_t e_{j,t} + \tau_{c,t} P_t^C C_{j,t} + \tau_{r,t} r_t A_{j,t}) = P_t^C G_t \tag{17}$$

where G_t is the government expenditures at time t.

The government also manages the public pension system, which is initially modeled as a pay-as-you-go (PAYG) scheme for the benchmark economy. Under a PAYG system, the government grants a fixed pension benefit to the retired generations, while pension contributions are completely

financed by the current working generations. The pension benefits are determined as a fraction of the lifetime average wage earnings from age 21 through the previous age of retirement. The fraction is given by the replacement rate, ψ, which is assumed to be identical across the region. Aggregate pension benefit is represented by equation (18):

$$PB_t = \sum_{j=45}^{65} N_{j,t}[\psi(\frac{1}{44}(\sum_{k=1}^{44} w_{t-j+k} e_k))] \tag{18}$$

Aggregate pension contribution, shown in equation (19), is determined by the product of the population of working group N_j, social security tax rate τ_p, and labor income $w_t e_j$.

$$PC_t = \sum_{j=1}^{44} N_{j,t} \tau_{p,t} w_t e_j \tag{19}$$

Because the pension budget constraint is balanced every period, $PB_t = PC_t$, the model can calculate the path of social security tax from the current working generation, which is endogenously determined.

Migration

The working population in model age group from 1 to 44 is assumed to be partially mobile across domestic regions. The net out-migration of labor is determined by the wage elasticity of labor migration, shown in equation (20):

$$M_t^w = POP_t^w (1 - \frac{w_t^{HOME}}{w_t^{ROUS}})^{\eta} \tag{20}$$

where M_t^w denotes the number of net out-migration of labor at time t, POP_t^w is the aggregate stock of labor given at the beginning of time t, w_t^{HOME} and w_t^{ROUS} are the wage rates in Chicago (HOME) and the rest of the United States (ROUS), and η refers to the wage elasticity of labor migration.

The stock of effective labor L_e is defined as the number of net workers, N_t^w, times their corresponding productivity level, e_j, as shown in equation (21):

$$\begin{aligned} L_{e,t} &= \sum_{j=1}^{44} (POP_{j,t}^w - M_{j,t}^w) e_j \\ &= \sum_{j=1}^{44} N_{j,t}^w \cdot e_j \end{aligned} \tag{21}$$

Retirees aged over 65 are assumed to migrate from one region to the other region with the exogenously given rate ε, where M_t^R and POP_t^R are the number of retiree migrants and total retirees population at time t, respectively, shown in equation (22):

$$M_t^R = \varepsilon \cdot POP_t^R \tag{22}$$

Market Clearing Conditions

Two equilibrium conditions close the model. First, the equilibrium conditions for the goods market must hold, which states that domestic output is equal to total demand from household, C_t; government, G_t; and firms, I_t, shown in equation (23):

$$\begin{aligned} D_t &= C_t + G_t + I_t \\ &= [\sum_{j=1}^{65} (N_{j,t}^{HOME} \cdot C_{j,t}^{HOME} + N_{j,t}^{ROUS} \cdot C_{j,t}^{ROUS})] + G_t + K_t - (1-\delta) K_{t-1} \end{aligned} \tag{23}$$

The second condition is equilibrium in the financial market. A financial market equilibrium condition ensures that the stock of assets accumulated by all individuals must be equal to the sum of the capital stock used in both regions, shown in equation (24):

$$A_t^{HOME} + A_t^{ROUS} = K_t^{HOME} + K_t^{ROUS} \tag{24}$$

Data and Calibration

One key issue 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 what is observed in the data. The calibration of the model is basically conducted to replicate the equilibrium conditions in the base year, which is 2005 in this model. Because national values are easily obtained from the accessible national data set like National Income and Product Accounts and previous studies (Brown et al., 1992; Kouparitsas, 1998), the following text mainly describes the choice of regional parameters.

Steady state conditions and the microconsistent data set for the Chicago region are obtained mostly from the Chicago Social Accounting Matrix (SAM) constructed by IMPLAN[11] and Illinois input-output multipliers and Chicago input-output tables prepared by the Regional Economics Applications Laboratory at the University of Illinois at Urbana-Champaign. Furthermore, a computable general equilibrium model for the Chicago region under a single representative household has been completed, and many of the parameters for this model are used in this two-region system.

Some regional parameters that appear in the utility and production functions are obtained from the corresponding national counterparts, because 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, following the estimates established by Hurd (1989) and Imrohoroglu et al. (1999).[12] The subjective discount factor is chosen by $1/(1+\rho) = 1.011$, 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 line suggested by previous studies. The depreciation rate, δ, and the technology parameter, *A*, for both Chicago and the ROUS are set at 0.069 and 1.005, respectively. The labor share of output, α, for Chicago is calibrated using Chicago SAM, yielding a value of 0.66, instead 0.69 for the ROUS.

For the demographic data set, the population change by age cohorts until 2050 is obtained from the projections provided by the United Nations (U.N.) and the Illinois Department of Commerce and Economic Opportunity. The conditional survival probabilities, *s*, are taken from Faber (1982) These estimates imply 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 2005. And, 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 (1991).

[11] IMPLAN (www.implan.com) provides annual data for U.S. counties and states as well as nonsurvey input-output and social accounts.

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

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 replacement rate for the base year is taken to be 50 percent of the average wage income, which matches its empirical counterpart.[13]

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[13] Conesa and Krueger (1998) computed the replacement rate of 50 percent using social security payroll tax and Old-Age Survivors Insurance data for the United States.

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