AGING AND THE REGIONAL ECONOMY: SIMULATION RESULTS FROM THE CHICAGO CGE MODEL

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Seryoung Park* and Geoffrey J.D. Hewings**

*Department of Economics and Regional Economics Applications Laboratory, **Departments of Geography, Economics and Urban and Regional Planning, Regional Economics Applications Laboratory and Institute of Government and Public Affairs, University of Illinois at Urbana-Champaign, 607 S. Mathews #220, Urbana, IL 61801-3671, USA spark2@uiuc.edu; hewings@uiuc.edu

Introduction

For many decades, the relationship between demographic transitions and economic growth has remained a subject of debates and generated a large volume of academic research. In earlier years, the main focus was on the impact of population size on economic growth. Debate centered on whether population growth restricts, promotes, or is independent of economic growth. Population pessimists (Coale and Hoover, 1958; Ehrlich, 1968) believed that rapid population growth was a threat to limited resources because a large part of investment had to be used to support the growing population. On the contrary, population optimists (such as Kuznets, 1967 and Simon, 1981) believed that a large population facilitated the realization of economies of scale and promotes technological innovation. However, population neutralists (Kelly, 1988) empirically showed that there was little cross-country evidence that population growth had either a significant positive or negative effects on economic growth. They argued that the correlation disappeared once other major influences, such as country size, openness, educational attainment, and political institutions, were taken into account.

All these theories, however, paid little attention to the age structure of population and its influences of the economic growth. In recent years, economists have tended to focus on population dynamics beyond population growth itself. More studies have decomposed the population growth in terms of fertility and mortality components and, more importantly, examined impacts on age distribution and economic growth. Since individuals behave differently at different stages of life, changes in the age structure in the economy can have an immediate effect on economies. For example, a country with a high proportion of the elderly might experience slower economic growth, because a large share of resources has to be allocated to support the less productive population. This potentially negative impact is the main problem associated with an aging population and will become a phenomenon experienced in many developed economies within a next few decades.

Future demographic changes, arising from an aging population, have attracted a lot of attention because of their sizable and rapid transitions. In particular, considering their significant economic impacts, there has been an explosion in research on many aspects of the aging population. However, most of these studies on economic consequences of aging population have been conducted at the national level, so that their results fail to capture the local effects of demographic changes due to the existence of the regional differences in terms of economic and demographic structures. The next question is closely related to the region-specific demographic changes which is an important but widely ignored influence of the aging population. Although an aging population is a nation-wide phenomenon that will affect all regions, it could significantly alter the interregional demographic structure through significant asymmetric migration flows among regions. For example, the migration of retirees will accelerate under an aging population, resulting in fundamental changes in the demographic structures of both regions of origin and destination. This issue is the least well understood demographic change which very few previous studies have addressed.

For this study, the Chicago region[1] is selected for a reference region since it has long been both a leading immigration place while 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,

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

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 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 retirees, because Chicago is the second largest loser, next to New York, in retirement out-migration. Moreover, over the next couple of decades, retiree migration may be expected to have a dramatic impact on the Chicago economy, because of the rapid transition to a status where the aging population will comprise a larger share of total population than at the present time.

Considering these issues, this chapter sets two main objectives. The first goal in this study is to improve our understanding about economic and intergenerational welfare conditions given the future demographic changes, with particular focus at the regional level. The second goal is to provide the sensitivity of these outcomes to selected policy reforms and suggest the policy implications to both local and federal government. This study would be the first attempt to rigorously quantify the dynamic effect of demographic changes on the regional economies.

This chapter is structured as follows. In the next section, attention will be directed to a discussion of the link between demographic changes and their economic impacts, with some empirical analysis derived from the Chicago economy. Thereafter, a review of the received theory and some prior empirical work that has explored formal demographic-economic interactions will be provided. The model is presented next and then the results focus on graphical presentation of the results of two scenarios, one in which no aging process is assumed and the other in which the expected pattern of aging is modeled. The analysis is centered on a two-region model of the Chicago economy (Chicago and the Rest of the US) although the results in this chapter ignore the influence of migration. A brief summary completes the chapter.

Demographic Changes and Economic Impacts

1 Aging Population

Over the next couple of decades, most industrialized countries including the United States are expected to face significant aging population problems as a large proportion of population moves from middle age to retirement. Although the ratio of elderly population is already rising due to increased longevity and lower birth rates, the effects of aging population are expected to become more pronounced with the aging of the baby-boom generations. In the case of the U.S., all 77 million baby boomers will have retired within 30 years, leaving twice the number of elderly. The significant rise in the proportion of the elderly population will lead to dramatic increase in the old age dependency ratio, which is defined as the ratio of the dependent old age populations (those ≥65) to the population in the working age groups (between 15 and 64). According to a United Nations projection of the evolution of the share of the population, the rise in old age dependency ratio in developed countries will be gradual until 2010, but increases at a much faster rate thereafter. For the United States, the dependency ratio is predicted to climb from 19 percent to 33 percent between 2000 and 2050.

Such an unprecedented demographic transition attributable to a sizable increase in elderly population should have a significant impact on economic performance. Especially, a significant loss in the working-age populations who usually exhibit higher productivity could generate a negative impact on the growth of per capita income unless sufficient technological progress has been made to compensate for the loss in labor resources. In addition to the shortage of labor supply, the aging population could have powerful impacts on savings and capital accumulation. Based on the classical life cycle theory of saving, proposed by Modigliani and Brumberg (1954), saving rises with income from labor supply during the middle ages, and declines and turns negative over the retirement period. As a result of this uneven pattern of savings over an individual's lifetime, a significant change in age structure under aging population may primarily alter the aggregate savings in the economy, and thus the economic growth. It is evident that an aging population could have a negative impact on aggregate savings because it increases the elderly population who usually dissave by consuming out of their savings. However, positive effects may also arise as a result of precautionary savings motives in anticipation of an extended lifespan. Here, it is assumed that individuals save more through private savings in order to provide for increased old-age consumption. Therefore, the overall effect on aggregate savings might be quite different according to the age structure of the population and an individual's optimal saving behavior. The different prediction for the impact of aging on saving will also generate various responses on capital stock, wages, and economic growth associated with the aging population. In addition to important macroeconomic effects, the aging population also puts tremendous financial pressures on current pension systems such as pay-as-you-go (PAYG) schemes. With a rapidly aging population, the pension contributions may not be sufficient to cover the total pension benefits which are expected to grow quite substantially. In order to finance the deficit of pension system, contribution rate may have to be raised, in some cases quite significantly. The implications here could be profound; however, they are not addressed in this chapter.

A further important consideration of the impact of an aging population is on migration. According to U.S. 2000 census, the total estimated number of retirement migrants, which are defined as migrants over the age of 60 who moved across the state lines, increased to over 2 million during the 1995~2000 period, which was 9 percent increase over the 1985~1990 period. In case of Illinois state, as a dominant migration origin, it has experienced heavy loss in elderly populations due to the retirement migration. Since the 1980s, more than 100,000 people age 60 and older in Illinois, which accounts for about 5 percent of state's cohort of population over 60 years old, out-migrate every 5 years. Considering the in-migrants, in 1985-1990 Illinois has experienced a net loss of 70,000 retirees, who were 60 and older, ranking the second largest among all the states. Further, the Chicago area accounts for over 80 percent of the older migrants who leave Illinois, i.e. Chicago region lose about 0.9 percent of old population, or about 12,000 retirees, every year. As the result, Illinois has lost more than one billion dollars a year in net income through retirement migration since the 1980s (Longino, 1995). The implications for the regional economy have been described in Park (2007).

2. Economic Implications

Most economic models, especially CGE models, devote relatively modest attention to the demographic side of the economy. In many cases, a representative household approach is adopted; hence, it is difficult, under these circumstances, to learn much about the dynamics of an aging population. In a precursor to the current chapter, Yoon and Hewings (2008) explored the implications of an aging population on the Chicago region by adopting a modified linear expenditure approach with several age cohorts (a further distinction was also made by income). Since the model employed was an econometric-input-output system, it was possible to trace the impacts of aging on consumption in total and to explore the ramifications of a changing mix of age cohorts on the way in which expenditures would be made across a set of goods and services.

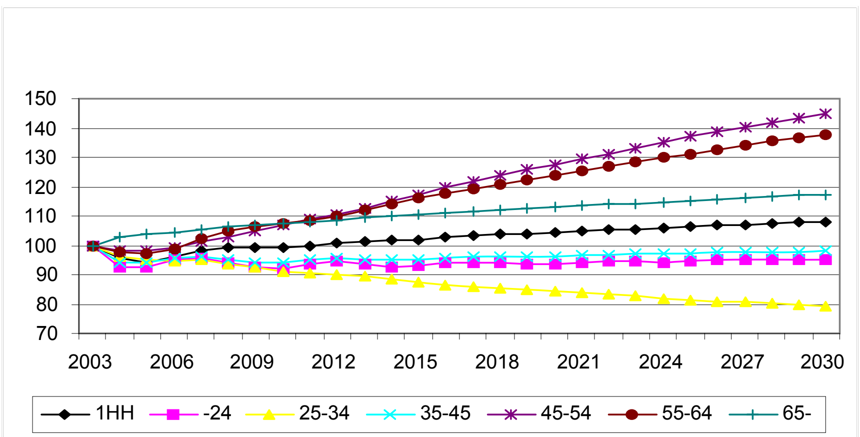
Table 1 provides a sample of the results obtained for the allocation of income across a selection of goods and services by different age groups for selected years through 2030. There are some obvious changes across age groups and over time; for example, all age groups can expect to allocate a larger share of total expenditures on health care but some of the largest percentage increases occur in the 45-54 and 55-64 age groups. The decline in food expenditures is compensated by an increase in the "Other" category wherein can be found restaurants; hence, it is anticipated that less food will be purchased for consumption at home.

Fig.1 shows how these different age-cohort households consumption will be expected to grow over time, in comparison to the growth of the representative household. The spread in growth rates is significant (confirmed by formal tests) and given the combination of changing numerical composition of these households in the region, the intersection of different growth rates and allocations across goods and services generates different impacts on the region's economy than the consumption effects from a representative household.

The combination of an aging population and the changes in consumption from income generate important growth patterns in the middle and higher age cohorts while the younger cohorts exhibit a declining rate of growth. However, these results are presented for an economy in which only modest migration effects have been considered. As Wakabayshi and Hewings (2007) demonstrated for Japan, the impacts of aging in the absence of significant in-migration are very different from cases in which in-migration might provide a source of younger, active entrants into the labor force.

Table 1. Consumption by Age: Selected Goods and Services by Year, Chicago

Consumption Types		Total	Under 25	25 - 34	35 - 44	45 – 54	55 – 64	Over 64
Food	2003	12.8	14.5	12.7	13.0	12.4	12.3	13.0
	2010	12.9	14.7	12.8	13.1	12.1	13.4	12.7
	2020	10.7	14.8	11.3	11.7	11.5	11.3	8.7
	2030	8.5	14.8	9.3	9.9	11.3	7.8	4.6
Housing	2003	36.3	34.1	39.0	37.6	34.4	34.4	36.7
	2010	37.0	36.0	40.2	38.6	35.9	34.3	37.1
	2020	37.4	34.4	41.9	40.7	38.7	34.6	36.1
	2030	36.7	32.3	43.4	43.3	41.2	35.3	35.3
Clothing	2003	4.3	5.2	4.8	4.7	4.2	3.8	3.3
	2010	3.5	5.1	4.5	4.2	3.8	3.5	3.0
	2020	2.3	4.2	3.9	2.9	2.7	2.6	1.9
	2030	0.3	2.7	3.1	0.5	0.9	0.8	0.4
Transportation	2003	16.9	18.1	17.7	16.7	17.3	17.6	14.7
	2010	16.5	17.9	17.6	16.8	17.4	17.7	14.0
	2020	17.0	18.9	19.2	18.2	18.6	19.7	13.1
	2030	17.7	20.4	21.4	20.2	20.1	22.3	12.6
Health care	2003	5.2	2.1	3.2	3.9	4.4	6.2	11.3
	2010	5.6	2.2	3.1	4.2	4.8	6.4	11.8
	2020	6.0	2.2	3.5	5.0	5.3	7.1	12.3
	2030	6.4	2.3	3.7	5.9	5.9	8.1	12.9
Others	2003	13.7	8.2	12.3	13.7	15.7	14.9	12.3
	2010	13.6	7.8	12.1	12.8	14.9	15.5	13.3
	2020	13.2	8.0	11.1	10.8	12.8	15.0	19.8
	2030	13.0	8.4	10.1	8.7	10.2	14.5	25.8



Note: 1HH is the single representative household

Fig. 1. Growth in Consumption 2003-2030 by Age-Cohort Households, Chicago

Received Theory and Prior Empirical Analyses

A large number of studies on the economic impacts of demographic changes already have been carried out embracing both empirical analysis and theoretical research.[2] The empirical studies primarily infer the economic effects of demographic transitions using cross-sectional survey data or microeconomic and macroeconomic time series data. However, the empirical literature has presented a mixed outcome of the impact of population aging on private savings and economic growth, in that the relationship between savings and the dependency ratio changes significantly, depending on the types of data and analyses used. Basically, cross sectional studies suggested a strong negative effect of the dependency ratio on the savings rate, while time series studies for individual countries and studies using micro survey data yielded weak, or even positive, demographic effects on savings. For instance, using the pooled

[2] A survey on aging population and its economic impact can be found in Bosworth, *et al*. (2004).

time series data for 61 countries, Masson *et al*. (1998) obtained highly significant estimate suggesting that the dependency ratio causes a negative impact on the savings rate. However, analyzing the consumer expenditure survey data, Poterba (1994) and Canari (1994) found no empirical evidence that supports the strong effect of the dependency ratio on savings rates.

The main drawback of these empirical studies is that they do not provide the explicit mechanisms that link the changes in individual optimal behavior associated with demographic transitions to the changes in macro-economic variables. In general, demographic changes affect the economy through the several complicated interactions and feedback mechanisms between economic agents. Thus, the complete economic implications of demographic changes cannot be adequately derived from the partial equilibrium approaches that characterize many of the empirical analyses. Considering this limitation, most recent papers on the effects of demographic changes have been carried out with a general equilibrium framework that contains detailed information about all commodities and factor markets together with each agent's decision making process.

Much of the general equilibrium model is based on the standard overlapping generations (OLG) model, originally introduced by Samuelson (1958) and Diamond (1965). Unlike the single representative model, OLG model includes intragenerational heterogeneity and a much more detailed specification of demographic structure by incorporating a more realistic pattern of births and length of life. However, in earlier studies, the obstacle to overcome in working with overlapping generations models was the heterogeneity implied by the age structure of the population. Auerbach and Kotlikoff (1987) offered a breakthrough in overcoming this obstacle by developing a tractable framework with a reasonable demographic structure. Since then, their model has been widely applied to the analysis of economic questions, arising from demographic changes, policy reforms, and endogenous growth.

More recently, several contributions have been made to modify and improve the earlier version of the model by incorporating many rich components such as uncertainty with respect to income and lifetime, liquidity constraints, endogeneity of labor market, and openness. Uncertainty without perfect annuity market exerts a major influence on the pattern of savings because of the timing of death or unemployment, and the limited options against unforeseen contingencies. Liquidity constraints will also change the implication for saving behavior by limiting saving against expected future income. As a pioneer of these types of model, Imrohoroglu *et al*. (1995, 1998) and Conesa and Krueger (1999) analyzed the quantitative role of uninsured idiosyncratic uncertainty with respect to individual labor productivity and lifespan in an overlapping generations model to investigate optimal pension reforms.[3] Gertler (1997) made substantial progress toward developing a more realistic overlapping generations framework where agents move stochastically into retirement, and once in retirement, face a constant mortality risk. This extension with life time uncertainty, pioneered by Blanchard (1985), is not only more realistic in terms of its demographic structure and life-cycle features, but also it opens up new applications that consider both aging population and fiscal policy implications. Morrow and Roeger (2004) applied this framework to investigate the effects of demographic transitions and pension reforms in Europe. Keuschnigg and Keuschnigg (2004) incorporate endogenous labor supply combined with employment search to capture the potential labor market distortions of pension reforms.

In these studies, however, demographic transitions have been analyzed in closed economy models that ignore immigration and accordingly international capital mobility. More recent studies have begun to address these issues. For example, Storesletten (2000) investigated the fiscal effect of immigration policies in the U.S. adopting an open economy feature in an OLG framework. Ingenue (2001) divided the world into six regions which have different demographics to examine the effect of global demographic transition on international capital flows. Fehr *et al*. (2004) developed a three-country version of the model with intergenerational earnings heterogeneity, bequests motives, and capital adjustment costs to quantify the macroeconomic and welfare effects of skill-specific immigration policy during the demographic transition.

However, even with these significant advances in the international models, very few studies have conducted both theoretical and numerical evaluations of the relationship between demographic changes and regional economies. One of the biggest obstacles in dealing with regional models is the complications arising from greater openness.[4] For example, labor is more mobile among regions within a nation than between countries, demanding a quite different treatment of labor mobility. Also, the influence of savings by residents in a region can spread to investment in other regions, generating differences between the region of factor employment and the region of expenditure of factor income. In addition, complex interactions between federal and local governments add complications for regional modeling. Reflecting these complexities, the first attempt to analyze the interregional consequences of an aging

[3] Imrohoroglu *et al*. (1995) found that the maximum benefit of social security occurs at a replacement rate in the neighborhood of 30 percent. And Conesa and Krueger (1998) argued that a majority of current voters would lose along the transition and therefore favor the status quo.

[4] For details, see Partridge and Rickman (1998)

population in the context of overlapping generation framework was very recently conducted by Fougere *et al*. (2004). They setup a six region OLG model for Canada to evaluate the effects of raising the proportion of immigrants and found that the effects on real-per capita output vary substantially depending on the regions. However, their model does not consider the labor mobility since it treats labor as completely immobile between regions; thus, it excludes all the efficiency issues associated with the regional movement of labor. Moreover, it basically adopted the standard overlapping generations framework neglecting the uncertainty issues which are closely related to saving motives against idiosyncratic risk.

Moving the interest to regional demographic changes under an aging population, there appears to be a dearth of previous studies. In particular, there appear to be no studies relating the impacts of retirement migration under aging population on the regional economy in the context of general equilibrium framework. Instead, most of the studies have analyzed the specific economic impacts based on empirical evidence such as cross-sectional surveys and macroeconomic time series. Serow and Hass (1992) used the survey data collected from retirees who have recently moved into the North Carolina and macroeconomic data at the county level. They find that migrants of retirement age make substantial contribution to the local economy in terms of income, job creation, and local government revenues. More recently, Day and Barlett (2000) examined the association between elderly in-migration and regional economic growth for Texas Hill Country counties. They found that counties that have become more retiree-oriented have experienced significantly more economic growth.

The Model

The model to be presented has been developed for use in analyses of the impacts of aging, migration and the fiscal issues associated with the optimal funding of social security and retirement programs. However, in this chapter, only the aging issues will be featured but the complete model structure will be described to provide a sense of the ways in which the CGE framework has been expanded.

This model is represented by the two-region dynamic general equilibrium model with an overlapping generations framework, whose national version was originally developed by Auerbach and Kotlikoff (1987). Like the original version, this model incorporates individual earnings heterogeneity, demographic transitions, and social security system. However, there are some novel features that are differentiated from former overlapping generations framework in two ways. First, this model newly introduces consideration of regional features that 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 is critically important to generate realistic implications of the effects of demographic changes. Detailed features are presented in the following section.

1 Features of the Model

1.1 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[5] 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 staying in the region where they originally reside.[6] This locational preference is represented by the wage elasticity of labor migration. With partial mobility of the labor, wage differentials

[5] Since each household consists of one agent in this model, "household" and "individual agent" will be used interchangeably.

[6] 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.

between regions take multiple periods to be adjusted because of the lagged responses of labor market. However, capital is assumed to be immobile interregionally.[7] 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 Armington assumption, a good produced in one region is treated qualitatively different from good produced in other regions. Thus, 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 elasticity.

1.2. 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. This model is constructed based on the dynamic OLG 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, only less than 3 percent of U.S. population is not considered.[8] 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 age 85, and leaves accidental bequests since annuity markets are assumed to be missing.[9] 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 the 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 individual 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.

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

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

[9] 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.

2 Technical Description of Model Structure

2.1 Household Sector

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

Representative agents of each age cohorts 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*.

$$U_i = \sum_{j=1}^{65} (\frac{1}{1+\rho})^{j-1} [\prod_{k=1}^{j} s_k] \frac{(C_{i,j})^{1-\gamma}}{1-\gamma} \qquad (0.1)$$

where $C_{i,j}$ is the aggregate consumption of an individual of age *j* in i_{th} generation, ρ is the subjective discount rate, γ is the inverse of the intertemporal elasticity of substitution. Thus, the effective discount rate is expressed as $(\frac{1}{1+\rho})^{j-1} \prod_{k=1}^{j} s_k \frac{1}{1-\gamma}$, 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, i.e. 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/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.

$$e_j = \lambda_1 + \lambda_2 j - \lambda_3 j^2 \qquad (0.2)$$

With the maximization procedure, the following standard first-order conditions can be derived, concerning consumption per period. Equation (0.3) implies that the marginal rate of substitution between consuming now and consuming later equals the relative price of consuming later instead of now.

$$C_{i,j} = \left(\frac{1+r_t}{1+\rho}\right)^{\frac{1}{\gamma}} \left\{\frac{P_{t-1}^C (1+\tau_{c,t-1})}{P_t^C (1+\tau_{c,t})}\right\}^{\frac{1}{\gamma}} C_{i,j-1} \qquad (0.3)$$

$$C_t^A = \sum_{j=1}^{65} N_{65-j+1,t} C_{t-j+1,j}$$

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

The following wealth accumulation equation can be obtained with the maximization procedure where A_t is the aggregate asset at time *t*.

$$a_{i,j} = a_{i,j-1}\{1+(1-\tau_{r,t}) r_t\} + (1-\tau_{w,t} - \tau_{p,t}) w_t e_j + pen_{i,j} - (1+\tau_{c,t}) P_t^C C_{i,j} + \Phi_t \qquad (0.4)$$

$$A_t = \sum_{j=1}^{65} N_{65-j+1,t} a_{t-j+1,j}$$

Once 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 CES composite of two regional goods.

$$\min P_s^C C_{i,j,s} = p_s^{HOME} c_{i,j,s}^{HOME} + p_s^{ROUS} c_{i,j,s}^{ROUS} \tag{0.5}$$

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 US (ROUS) produced good at region s, β_s is the consumption share parameter for good produced in region s, and φ_s is the parameter that controls taste for variety. Optimal consumption of differentiated good between imports and domestic good takes the following forms:

$$c_{i,j,s}^{HOME} = \beta_s \left[\frac{P_s^C}{p_s^{HOME}} \right]^{\sigma_s} C_{i,j,s} \tag{0.6}$$

$$c_{i,j,s}^{ROUS} = (1-\beta_s) \left[\frac{P_s^C}{p_s^{ROUS}} \right]^{\sigma_s} C_{i,j,s}$$

where σ_s is the Armington elasticity of substitution for consumption in regions s between home made good and imported good[10]. Equation (0.6) implies that the demand by an individual of region s for a good produced in each region is function of the price of that good relative to the price of aggregate good and of the quantity of aggregate good the individual wants to buy.

Combining equation (0.6) with equation (0.5) yields the aggregate price (P_s).

$$P_s = \left\{ \beta_s \left[p_s^{HOME} \right]^{1-\sigma_s} + (1-\beta_s) \left[p_s^{ROUS} \right]^{1-\sigma_s} \right\}^{1/(1-\sigma_s)} \tag{0.7}$$

2.2 Production sector

In each region, there is a single representative firm, which 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.

$$Y_t = A K_t^{\alpha} L_{e,t}^{1-\alpha} \tag{0.8}$$

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 (0.9).

$$\pi_t = P_t^C Y_t - w_t L_t - P_t^C I_t \tag{0.9}$$

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:

$$\max \sum_{t=0}^{\infty} \left(\prod_{s=0}^{t} \frac{1}{R_t} \right) \pi_t \tag{0.10}$$

The first order conditions to this problem yield the factor demand conditions:

---

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 imperfect substitutes and prefer variety.

$$\frac{re_t}{P_t^C} = \alpha A K_t^{\alpha-1} L_{e,t}^{1-\alpha} \quad (0.11)$$

$$\frac{w_t}{P_t^C} = (1-\alpha) A K_t^{\alpha} L_{e,t}^{-\alpha} \quad (0.12)$$

$$R_{t+1} = (re_{t+1} + (1-\delta)) \frac{P_{t+1}^C}{P_t^C} \quad (0.13)$$

where *re* is rental return of capital. Equation (0.13) implies that the unique gross interest rate is increased by rental return of capital and capital gains.

2.3 Government sector

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 follows:

$$\sum_{j=1}^{65} N_{j,t}(\tau_{w,t} w_t e_{j,t} + \tau_{c,t} P_t^C C_{j,t} + \tau_{r,t} r_t A_{j,t}) = P_t^C G_t \quad (0.14)$$

where G_t is the government expenditures at time *t*.

The government also manages the public pension system, which is initially modelled as a pay-as-you-go (PAYG) scheme for the benchmark economy. Under 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 region. Aggregate pension benefit is represented by equation (0.15).

$$PB_t = \sum_{j=45}^{65} N_{j,t}[\psi(\frac{1}{44}(\sum_{k=1}^{44} w_{t-j+k} e_k))] \quad (0.15)$$

Aggregate pension contribution, equation (0.16), is determined by the product of the population of working group (N_j), social security tax rate (τ_p), and labor income.

$$PC_t = \sum_{j=1}^{44} N_{j,t} \tau_{p,t} w_t e_j \quad (0.16)$$

Since 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.

2.4 Migration

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.

$$M_t^w = POP_t^w (1 - \frac{w_t^{HOME}}{w_t^{ROUS}})^{\eta} \quad (0.17)$$

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 rest of the U.S. (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).

$$\begin{aligned} L_{e,t} &= \sum_{j=1}^{44}(POP_{j,t}^{w} - M_{j,t}^{w})e_j \\ &= \sum_{j=1}^{44} N_{j,t}^{w} \cdot e_j \end{aligned} \tag{0.18}$$

Retirees aged over 65 are assumed to migrate from one region to the other region with 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.

$$M_t^R = \varepsilon \cdot POP_t^R \tag{0.19}$$

2.5 Market Clearing Conditions

There are two equilibrium conditions that close the model. First, the equilibrium conditions for good market must hold, which states that domestic output is equal to total demand from household (C_t), government (G_t), and firms (I_t).

$$\begin{aligned} D_t &= C_t + G_t + I_t \\ &= [\sum_{j=1}^{65}(N_{j,t}^{HOME} \cdot C_{j,t}^{HOME} + N_{j,t}^{ROUS} \cdot C_{j,t}^{ROUS})] + G_t + K_t - (1-\delta)K_{t-1} \end{aligned} \tag{0.20}$$

The second condition is equilibrium in the financial market. Financial market equilibrium condition assures that the stock of assets accumulated by the all individuals must be equal to the sum of the capital stock used in both regions.

$$A_t^{HOME} + A_t^{ROUS} = K_t^{HOME} + K_t^{ROUS} \tag{0.21}$$

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 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 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 under single representative household has been completed and many of the parameters for this model are used in this 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 same type of household preferences and production function across regions. For example, coefficient of relative risk aversion is chosen by $\gamma = 1.91$ following the estimates established by Hurd (1989) and Imrohoroglu *et al*. (1999).[11] 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 region and rest of the US

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

are set at 0.069 and 1.005, respectively. The labor share of output (α) for Chicago region is calibrated using Chicago SAM, yielding a value of 0.66, instead 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. 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) 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). Replacement rate for the base year is taken to be 50 percent of the average wage income, which matches its empirical counterpart.[12]

IMPACTS OF AGING POPULATION

In this section, aging population is addressed as one of the main sources of local demographic changes. First, the simulated results with no aging are described as the Baseline Scenario, and then, these results are compared with the simulation results under aging population.

1. Baseline Scenario

The baseline simulation basically assumes that there is no change in population structure. It runs with the age distribution and population growth rate unchanged forever from their 2005 levels, keeping other parameters at their base levels. Also, it is assumed that there are no changes in public policies on immigration and pension systems.

Figs. 2 through 7 summarize the simulated optimal decisions by the age cohorts, represented as an individual agent living in Chicago region. The following describes the simulation results on asset holdings, income, saving, and consumption in turn. The classical life-cycle theory predicts that each individual who has to provide for old age consumption from his private savings accumulates a certain amount of assets during the working age. Fig. 2 shows that assets increase from the mid 20s until around retirement, and then declines steadily to zero by death as classical life-cycle predicts. Fig. 3 shows the income profiles by age. Total income, which includes wages, capital income from savings, and pension benefits, continues to rise until the age of mid 50s, when wage income reaches its peak, and then drops abruptly at the time of retirement.[13] After retirement, income declines gradually due to the decrease in asset holdings. When we look at the income by age and its composition, before retirement, wage income accounts for more than 70 percent of the total income, while capital income captures a small slice of total income. However, after retirement, pension benefits replace the small fraction of wage income. During the early retirement period, capital income and pension benefits compose the total income with approximately equal shares. However, approaching the oldest age, capital income falls relatively fast as the stock of assets declines, while the pension benefit is constant. Thus, the pension benefit is significantly responsible for the total income of the oldest generations.

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

[13] If the retirement decision was endogenous and hours of work could be gradually adjusted after retirement, then average income would not change abruptly at retirement.

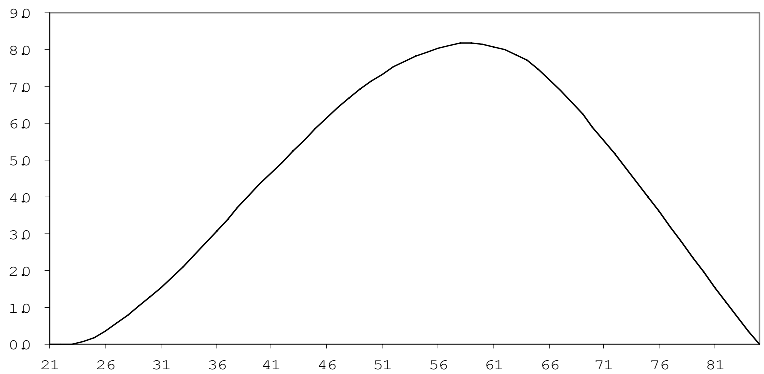


Fig. 2 Baseline simulation results (no aging): Assets

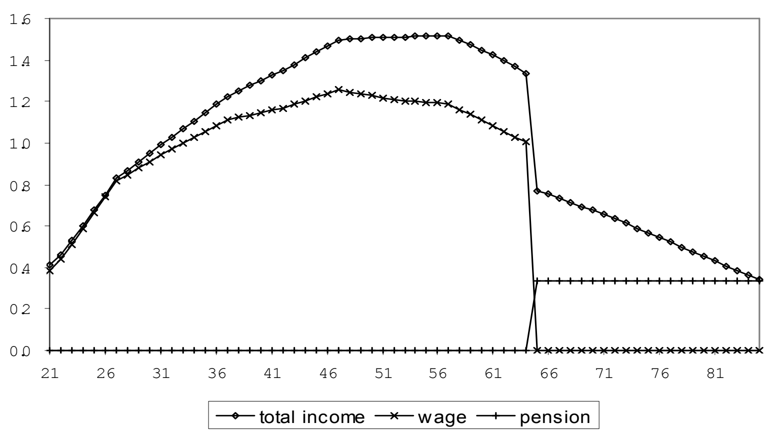


Fig. 3 Baseline simulation results (no aging): Income

Fig. 4 Baseline simulation results (no aging): Saving

Fig. 4 depicts the optimal pattern of lifetime saving. Individuals save assets between their mid 20s and early 60s and then begin to convert them for consumption during retirement. Especially, the oldest show strongly negative saving motives because they expect their remaining lifetime to extend with lower uncertainty, i.e., older retirees have a higher marginal propensity to consume out of their lifetime savings than workers and younger retirees. This saving pattern over the lifetime fundamentally coincides with the consumption smoothing motive, i.e., individuals tend to save more early in their lifetime and postpone consumption later when the retirement reduces the income.

Similarly, the saving rate (fig. 5), defined as household savings as a percentage of disposable income, turns from a positive to a negative value around retirement.

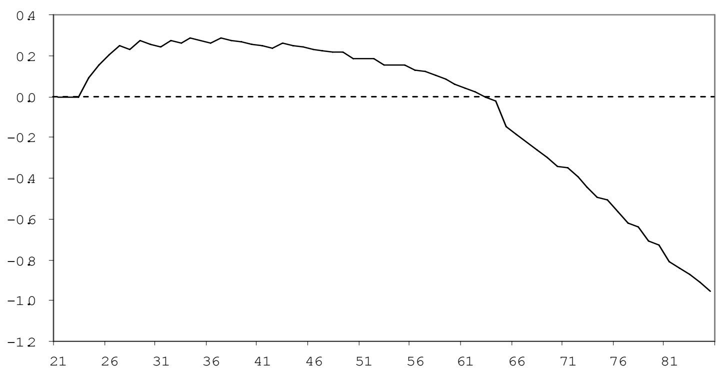


Fig. 5 Baseline simulation results (no aging): Savings rate

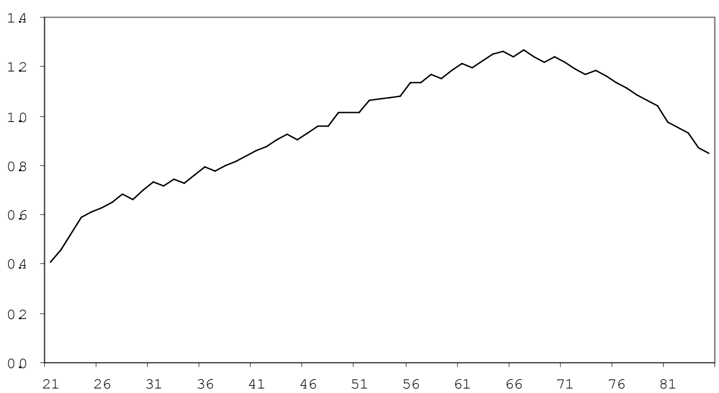


Fig. 6 Baseline simulation results (no aging): Consumption

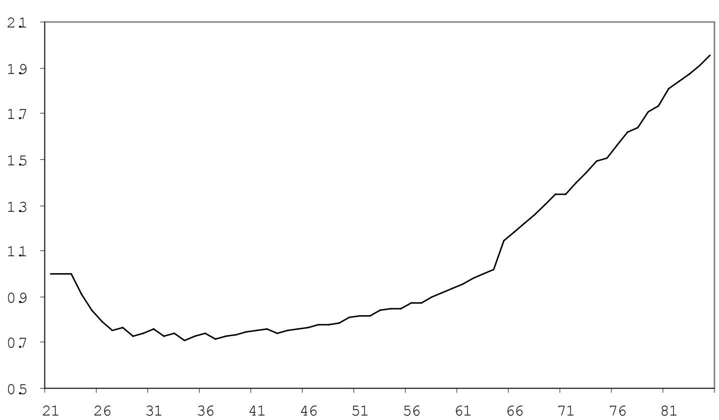


Fig. 7 Baseline simulation results (no aging): Consumption propensity

Figs. 6 and 7 show the age profiles of consumption and its propensity. The consumption profile by age is smoother than the income profile. The level of consumption starts to rise from the youngest age, and keeps rising around the retirement age. After retirement, consumption starts to decline because retirement is a greater negative shock to income resources. However, retirees keep the consumption at the level of the mid 30s, though this gradually decreases to the end of life. As a result, the consumption propensity, defined as household consumption as a percentage of disposable income, shows a reversed lifetime pattern in comparison to the level of consumption. It moves around 0.7~0.8, which implies 70~80 percent of disposable income is spent for consumption, until middle age and then increases to 1.2~1.8 during retirement.[14] This result yields a very important implications for the economic conditions under aging population. It implies that once a large portion of baby-boomers retire around the year 2030, they will account for significant part of aggregate demand in the economy. Moreover, this result suggests that heavy losses in the elderly population through retirement out-migration, the experience of some larger metropolitan regions like New York and Chicago, could seriously hurt the local economic growth over the next couple of decades since the elderly out-migration is expected to substantially increase with aging population.

2. Aging Population

This section investigates the effects of aging population primarily on the economy of the Chicago region, reflecting the fact that the overall effect of aging population on the rest of the U.S. is basically similar to the Chicago region. Demographic changes associated with aging population are introduced by replicating the U.N. projected dependency ratio. The replacement rate is held constant at 50 percent over the entire horizon. It is assumed that the aging population is not expected in the base year, which is 2005, when the economy is in the initial steady state.

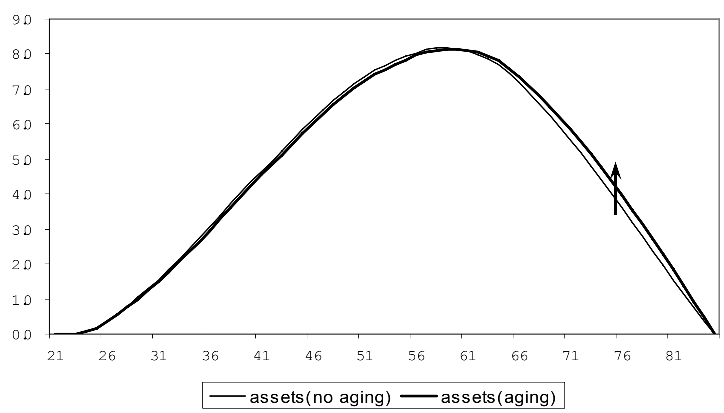


Fig. 8 Aging simulation results: Assets

Figs. 8 through 13 compare the projected results from the simulations with and without aging population. For asset holdings, aging population appears to put upward pressure on the asset holdings (see fig. 8). This happens basically because individuals in this economy who save through private saving in order to provide for old-age consumption, are motivated to accumulate additional assets in response to increasing life expectancy. However, the increase in assets is not large enough, especially during most working age periods; hence, accumulated assets do not change significantly before and after aging population.

[14] The pattern of this simulated age-consumption propensity is very similar to the empirical counterpart reported by Yoon and Hewings (2008), who used CREIM (Chicago Region Econometric Input-output Model). However, the simulated profiles for retired persons appear to have relatively higher propensities. This can be attributed to the fact that the bequest motive does not exist, so, accumulated wealth has to be completely exhausted before death.

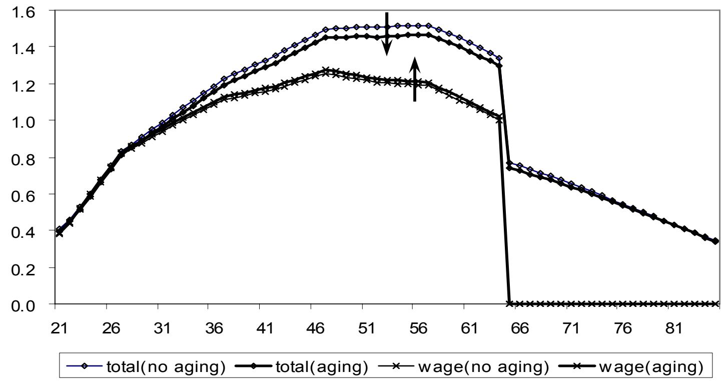


Fig. 9 Aging simulation results: Income

Fig. 10 Aging simulation results: Saving

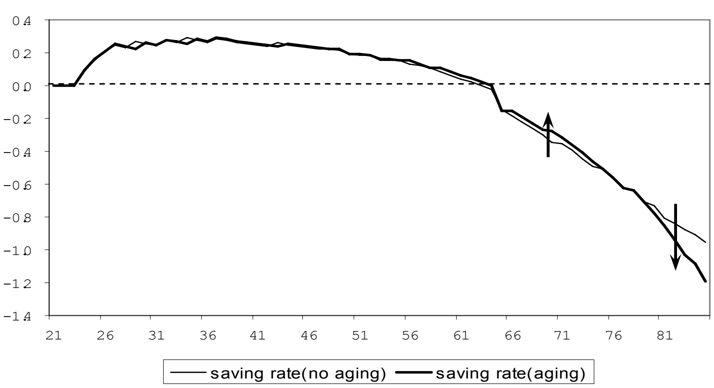


Fig. 11 Aging simulation results: Savings rate

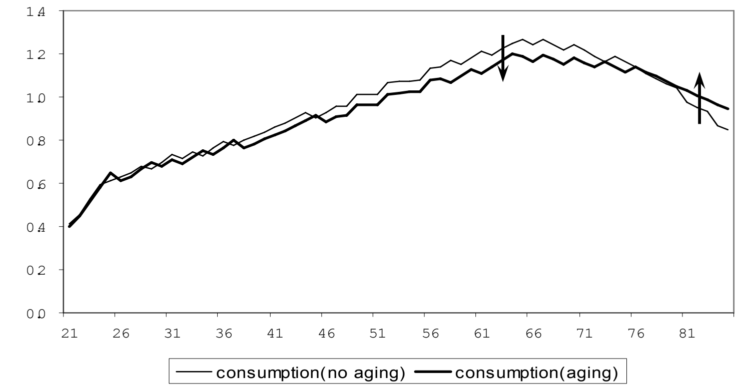


Fig. 12 Aging simulation results: Consumption

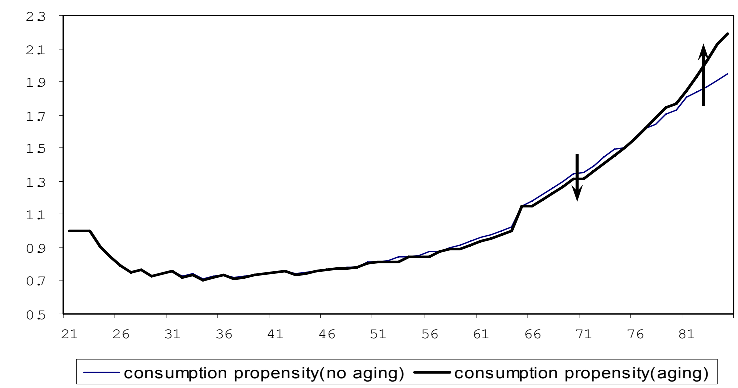


Fig. 13 Aging simulation results: Consumption propensity

Total income (fig. 9) also changes under aging population, but moves in a somewhat unexpected direction. Not surprisingly, untaxed wages increase under aging population, reflecting the relatively scarcity of labor. Nonetheless, total income decreases over almost all age cohorts. For working age cohorts, this happens because the sharp increase in social security tax under aging population reduces the net wage income from labor supply. For early retirees, though relatively smaller than workers, the fall in interest rate caused by relatively abundant capital contributes to reducing the capital income from savings. With these different changes in income by age, the effect of aging population on savings is also sensitive to the age cohorts. That is, before the retirement, the difference in saving is not large enough to generate major interest. The possible reason is that even aging population motivates precautionary saving for the working age cohorts; they cannot afford to sufficiently increase savings due to the fall in total income. Instead, young retirees reduce dissaving by cutting down their consumption, rather than accumulating more assets. However, the negative saving tendency among the oldest groups becomes much stronger under aging population. The changes in savings after aging population (figs. 10 and 11) have an important implication for economic growth because higher negative saving of the oldest population without supplementary saving from younger generations necessarily reduces the aggregate saving, which in turn decrease the aggregate capital stock in the economy. Consumption (figs. 11 and 12) under aging population drops significantly except for the oldest cohorts, reflecting a decline in total income and strong precautionary saving motives.

Figs. 14 through 21 summarize aggregate economic outcomes and their transitional path until 2070, when the economy converges towards the long-run steady state as the transition to aging population is completed. The first two graphs, figs. 14 and 15, show the evolution of the capital/labor ratio and wages, respectively. Aging population increases the relative number of old generations holding higher assets, while it decreases the relative number of young generation who supply labor. This demographic change explains most of the rise in the capital/labor ration under aging population. During the initial transition period, the sharp increase in the capital/labor ratio drives wages significantly above the base year wage level. However, since the capital stock decreases due to the reduction in aggregate savings as the aging deepens, the wage starts to fall gradually toward the new steady state value, which is still higher than the base year wage. This transitional profile of wages could generate unbalanced income redistribution between current middle-aged generations and younger future generations. Current middle-aged generations benefit from increased wage income and associated higher pension benefit, whereas current younger generations suffer from increased social security tax over the rest of their lives as well as smaller wages when they become middle-aged workers.

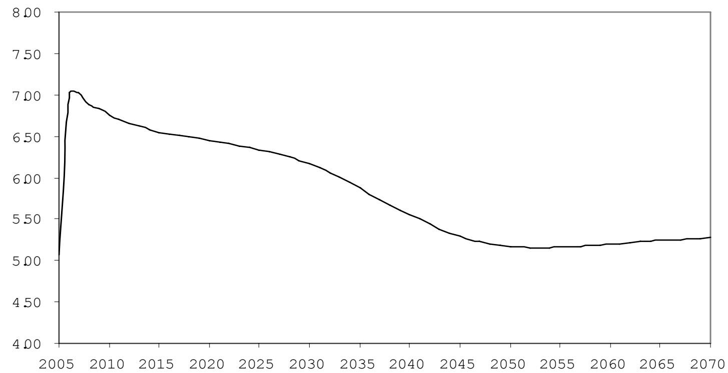


Fig. 14 Capital-labor ratio

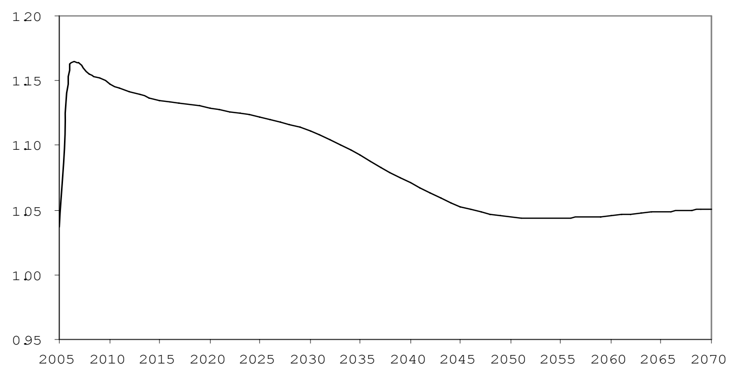


Fig. 15 Wages

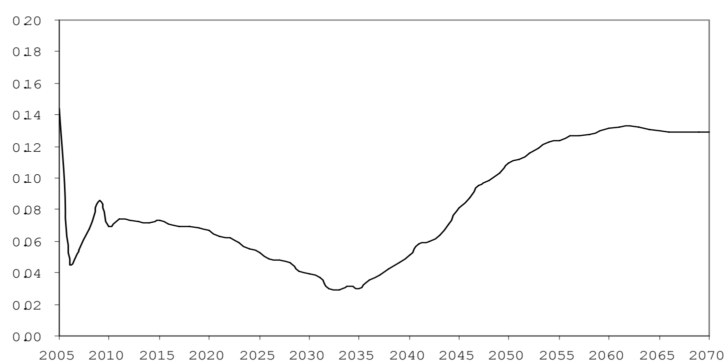


Fig. 16 Aggregate savings rate

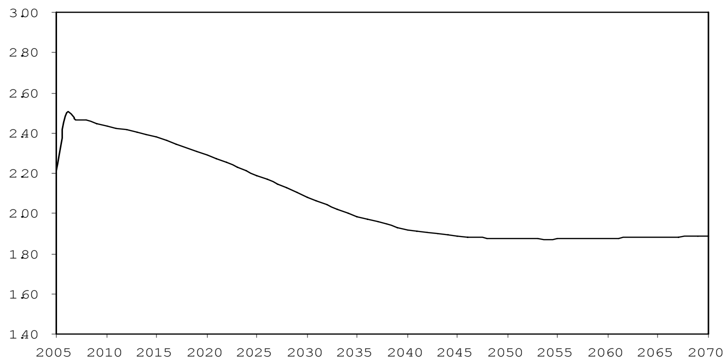


Fig. 17 Gross regional product

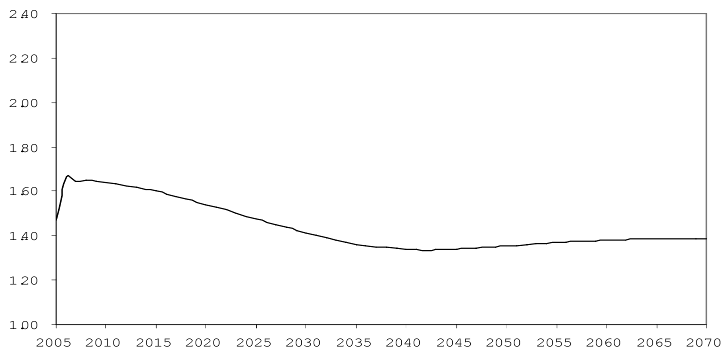


Fig. 18 Per capita gross regional product

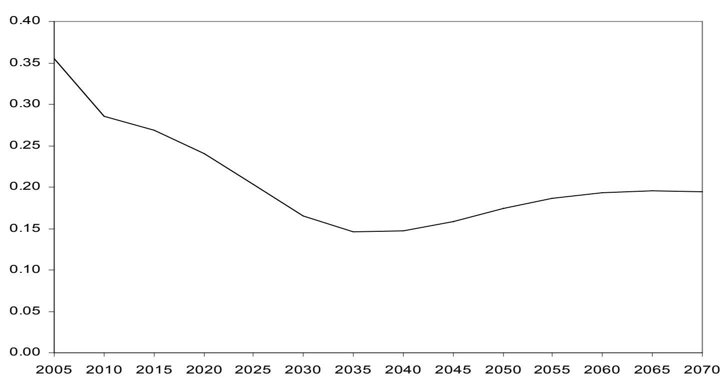


Fig. 19 Income Gini coefficient

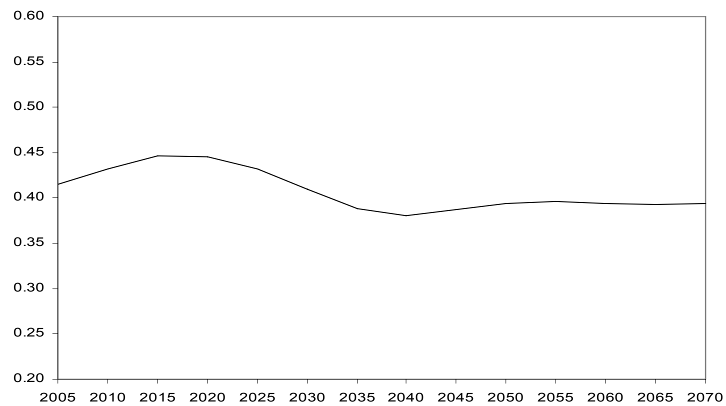


Fig. 20 Asset Gini coefficient

Fig. 16 plots the evolution of thr aggregate savings rate, which declines substantially and then decreases gradually after some rebound. The fall continues until the year mid 2030s, when the aging problem has the most profound impact; as a result, the aggregate saving rate in 2035 plunges to around 3 percent from around 14 percent of the base year. This result is consistent with other studies that show the significant decline in the savings rate with aging.[15] Although aging population will motivate the precautionary savings, the lower aggregate saving is somewhat expected looking at the modified individual's saving behavior after aging population. Two possible reasons can explain this result. The first is related to the change in population structure. Under aging population, since individuals postpone more consumption for old age when an individual shows a very strong negative propensity to save, an increasing share of the elderly under the aging population partially contributes to a decrease in the aggregate savings. The second reason is that the increase in social security tax rate will make it hard for young workers to increase sufficiently their savings.

Fig. 17 shows the transitional path of GRP. Basically, the fall in aggregate savings accompanied by the smaller labor force eventually leads to the fall in the GRP compared to the before-aging population. However, in the initial periods, the transition to aging population helps to increase the absolute level of effective labor and capital stock because baby boomers are still at work enjoying higher productivity and accumulating a larger amount of assets preparing for aging. Both the increases in labor and capital necessarily drive the regional output above the level of GRP before the aging population. However, in the subsequent period, GRP starts to decrease up to 2040s, and then converges at the level which is lower than approximately 9 percent compared to base year. This happens because after an initial overshoot, the capital stock starts to decrease gradually reflecting the fall in aggregate savings, and thus, two negative impacts, smaller capital stock and labor force, fuel the decline in GRP. The decreasing GRP leads to the fall in the per capita GRP in turn.

The last two graphs, figs. 19, 20, depict the Gini coefficients evaluated from income and asset distribution across age cohorts.[16] Following Dixon *et al*. (1987), Gini coefficient is computed by the relative mean difference, i.e., the mean of the difference between every possible pair of individuals divided by the mean size.[17]

According to fig. 19, before the aging population, the income Gini coefficient turns out to be 0.35, which is slightly lower than the actual measurement.[18] However, over the next several decades when the aging proceeds, the income Gini coefficient appears to decrease to around 0.20, implying that the aging population is likely to improve the equality in income distribution. This result is not consistent with a previous study (Yoon and Hewings, 2008), that predicted the deepened income disparity under aging population, reflecting the increase in income of the richest populations thanks to the higher wage and capital income from larger assets. This unexpected outcome is closely re-

[15] See, for example, Auerbach and Kotlikoff (1987), Miles (1999), and Shimasawa and Hosoyama (2004).

[16] Asset distribution could be an even more important indicator to measure the economic inequality, since the trend of distribution in the asset more fundamentally represents a measure of ability of household to consume. According to national data from U.S. census bureau, asset inequality has always been substantially greater than income inequality. Between 1983 and 1989, the top fifth received more than 75 percent of the total increase in income and 99 percent of the increase in asset.

[17] Gini coefficient (G) is computed as $G = \left[\sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_i - x_j \right| \right] / 2n^2\mu$, where μ is the mean size.

[18] According to the U.S Census Bureau, during the last three decades the income Gini coefficient has been around 0.4.

lated to the role of the social security system that is effectively ignored in the previous study. Before the aging population, retirees receive relatively much smaller income from social security benefit and asset holdings than rich middle-aged workers. However, under aging population, even with an increase in wages, the disposable income of the richest populations decreases reflecting the increasing pension contribution, whereas overall income of the retirees changes slightly thanks to the constant pension benefit and increased stock of assets. Further, an increasing share of older people under aging population contributes to a reduction in the income gap between high income workers and poor income retirees, resulting in a declining Gini coefficient. The improvement in income distribution as the aging proceeds results mainly from the strong income redistribution effect of the social security system by supporting the poorest old population at the expense of the richest working population. Therefore, this result implies a negative impact of pension reforms toward small benefit on equal income distribution, because they will reduce the public support for the old population.

Fig. 20 presents the Gini coefficients looking at the asset distribution. Unlike income distribution, the asset Gini coefficient increases, though it is not striking, as the aging population deepens, i.e. assets are more unequally distributed across the age cohorts. The possible reason for this phenomenon is that larger assets to compensate for the increasing life expectancy are concentrated in the population groups in their 50s and early 60s, who already have accumulated a large stock of assets before the aging, while most of young workers are relatively less able to accumulate enough assets to prepare for their increasing life expectancy due to liquidity constraints.

Conclusions and Further Analysis

The analysis presented in this chapter offers some insight into the complex interactions between demographic processes and the economy. The simulations focused on a regional economy that changed little in terms of the age structure (baseline scenario) in contrast to a more realistic case in which the proportion of the population greater than 65 would increase rather significantly, following expected developments for the US economy. The outcomes reveal some important characteristics of the aging process, producing some expected and some surprising results.

The analysis here is the first stage of a more complete simulation of the regional economy under conditions of aging; when consideration is given to interregional and international migration and the very complex issue of funding social security, the picture becomes even more complicated (see Park, 2007). However, it is here that the nexus of some of the more important policy debates is likely to be centered and regional analysis can no longer retreat behind models that do not handle at least some of the complexity associated with the demographic influences on the economy.

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