# The international impact of population aging on Mexico:

# An OLG model application in a small open economy

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## Abstract

This paper examines the impact of the demographic shock on some macroeconomic variable of Mexico under both the small open and the closed economy assumptions. To this model, I use a computable overlapping generations general equilibrium model developed by Fougère and Mérette (1998). In particular, I simulate the transition of the aging shock in the United States on the Mexican economy. The demographic projections are such that despite the fact that the Mexican population will remain younger than the American one, the population in Mexico will age more rapidly. The simulation results show that the slower aging process in the United States will alleviate the internal aging shock in Mexico.



Keywords: Demographic shock; OLG model; Real return on capital; Simulation.

# I. Introduction

The research on the demographic changes for developed countries is not a new field. Comparing with developing countries, the developed countries are experiencing an earlier demographic transitions and more advanced stages in the process of population aging. The change in the age structure of the industrialized countries is dramatic and will lead to a substantially higher proportion of older people. The fraction of the elderly population (over 65 years old) in these countries is projected to increase dramatically in the next 50 years. The labor force will decline as the so-called baby boomers retire and they may live longer as they have better health. Accordingly, the ratio of population outside of labor force to the working age population will increase significantly.

Population aging is expected to lead to important macroeconomic implications stemming from its direct and indirect effects on national savings, investment and public finance. It may have significative impact on the international capital market.

Indeed, the growth of global capital market and the important pension funds in developed countries might cause a higher level of capital flows from developed countries to developing countries. This kind of investment pattern can reduce the negative impact on returns on capital and savings of aging in those fast-aging countries. This is because returns on capital is negatively correlated to the capital-labor ratio. The labor force of fast-aging countries decreases, which causes an increase of capital-labor ratio. Accordingly returns on capital decreases. With the globalization of financial markets, people in fast-aging countries may look for investment abroad, further affecting the interest rate in the domestic monetory market, and current balances. Given these conditions, aging will affect the current account of less-aging countries through international trade and flows of capital and the impact maybe huge given the intensity of the aging process in rich and developed countries. Therefore, in this paper, I want to investigate the impact of the aging process in the rich and developed country on a small open and less developed economy. I want to analyze if the growing interdependency between developed and less developed countries will facilitate or not the economic adjustments necessary to face population aging. To do this, I intend to use a computable general equilibrium model with an overlapping generations structure.

The example I take will be the effect of aging in the U.S. on Mexico. The reason I chose Mexico as my study country is that Mexico is a developing country with a gradual population aging process. With a population of 98.8 million (The United Nations 1996), Mexico is now the second trading partner of the United States. Its exports to the United States in 1999 were $109.71 billion. (Bureau of the Census). As a member of the North American Free Trade Agreement (NAFTA), Mexico plays a more and more important role in the North American Area. I neglect to study the relation between Mexico and Canada, because the volume of international transactions between Mexico and the United States are much larger and the U.S. is a much bigger economy than Canada.

The paper is organized as the following: Section II reports recent Mexican economy performance. Section III presents the demographic facts in both Mexico and the United States. Section IV discusses some macroeconomic issues related to aging populations. Section V reviews some literature on the overlapping generations model (OLG). Section VI describes the OLG model in details. I explain the calibration procedure of the model in Section VII. Some simulation results are given in Section VIII. At the end of the paper, I summarize the results and make some concluding remarks.

## II. The Mexican Economy

As I am going to discuss the international impact of population aging on Mexico, I briefly review the evolution of the Mexican economy in recent years. Mexican economy seems to be comprised by repeated economic crisis and intervening periods of mild economic recovery. Over the last three decades, there have been four large economic crisis (in the late 1970s, the early 1980s, the mid to late 1980s and the mid 1990s). These crisis are characterized by sudden increase in inflation, unemployment and external imbalances and large currency devaluation. In 1983 the economic growth rate declined to –0.4 percent, in 1986 it fell to –2.6 percent, and in 1995 it was –4.4 percent. The inflation followed a similar way. It went from 42 percent in 1982 to 110 percent in 1983, from 74 percent in 1986 to 153 percent in 1988, and from 7 percent in 1994 to 41 percent in 1996.With respect to 1981, the real minimum wage declined 18 percent in 1983, by 13 percent in 1988 and by 12 percent in 1994. The steadily declining purchasing power of the minimum wage is caused by the substantially widen gap between prices and earnings.

However, the Mexican economic performance is now improving. The annual growth rate of Mexican economy in the past five years will be no less than 5 percent, which is the highest rate for a similar period in the past 20 years. The inflation also followed the similar way: It was 34.76 percent in 1995, 36.85 percent in 1996, 16.67 percent in 1999, and 10.55 percent in 2000. The Mexican economy has gradually emerged from the shadows of recession and moved into a recovery in 1995, especially in industrial production. While a few sectors are already improving a lot, overall GDP performance in 1995 remain weak. The GDP growth rate in 1995 was –6.15 percent. After 1995, overall GDP performance improves a lot. The GDP growth rate was 5.2 percent in 1996, 3.8

percent in 1999, and 7.9 percent in the first quarter of 2000. At the end of 2000, it is expected a real GDP growth rate in the range of 4.5 percent and 5 percent.

The export sector is growing rapidly. The exports were $39.93 billion in 1993, $49.49 billion in 1994, $74.29 billion in 1996, $94.71 billion in 1998, and $109.71 billion in 1999. To limit deterioration in the trade account and thus escape a repitition of the 1994 crisis, the government seeks to maintain a moderate and steady economic growth rate in a range of 3.5 to 4.5 percent.

The trade deficit during 1995-1999 averaged US$149.2 million, in contrast to an average of US$7.575 million between 1988 and 1994. Especially, the share of manufacturing exports averaged 86.6 percent of total exports during 1995-1999, in contrast to 75 percent in 1988-1994 period. Today, Mexico is the second trade partner of the United States, after Canada but before Japan. During the past five years, the ratio of the current account to GDP has averaged 1.97 percent, that is, within sustainable levels. In 1999, the current account deficit reached US$ 14.1 billion, 2.9 percent of GDP, 12 percent below the 1998 deficit and 52.3 percent below that of 1994. Between 1988 and 1994 the share of the current account deficit financed by portfolio investment averaged 57.9 percent. From 1995 to 1999 the current account deficit has been financed mostly through Foreign Direct investment (FDI) and, to a lesser extent, by public and private long-term foreign indebtedness, FDI inflows have averaged closed to US$ 11 billion per year during 1995-1999, which is 102 percent more than the average of 1990-1994.

As we all know, the North American Free Trade Agreement (NAFTA), which was envisioned as creating a $6 trillion market with more than 360 million consumers, was approved by the United States, Canada, and Mexico in 1993 and was implemented on January 1, 1994 (Carbaugh 2000).

The motivations for this agreement differ among three countries. Because I want to study the impact of aging in the United States on Mexico, I skip the motive of Canada here. For the United States the prime motive is political---to help set an economically strong Mexico as a model to the world and especially the heavily indebted or political unstable Latin American and Central American countries. There are also more economic concerns, for example: helping Mexican to migrate across the border and improving the growth prospects in some states such as California, Texas, New Mexico, and Arizona. But because of the relative size of the two economies, the whole economic impact of NAFTA is not very large for the United States.

For Mexico, the motive for the NAFTA is mainly economics. Because of the devastating experience initiated by the debt crisis, Mexican realize that trade liberalization is an effective means of fostering domestic reforms and achieving stable economic growth. The most important motivation is investment, which reflects some concerns of President Salinas who voiced in 1991 that Mexico desperately needs capital resources to achieve economic recovery and the Latin America would be deprived by the relative dearth of international investment caused by fast-growing demand from Eastern Europe.

With the globalization of international trade and the complementarity of economies, Mexico believe that it would compete more efficiently within the new North American market.

The Mexican economy is now more open to the world and is competing more fiercely to attract for greater capital flow and advanced technology. The NAFTA resembles a system where the relatively small Mexican economy competes with the large U.S. economy. Mexico has changed towards an outward-looking economy in which the mass of industrial production tends to locate near the border region.

With the elimination of barriers to imports and foreign capital, trade and investment linkages between the United States and Mexico have grown steadily in recent years. Over the past decades, Mexico's trade mix changed a lot with the diversification and the deepening of U.S. investment in Mexico. Export growth has been implemented in manufacture sectors whereas imports growth has been in intermediate good such as chemicals and equipment.

The NAFTA has allowed Mexico to play an important role in the U.S. markets for some commodities and assets. Because the current account balances of one country is one of the factor reflecting the capital change, investigating the impact of population aging in U.S.on the current account balances of Mexico is relevant.

## III. Demography

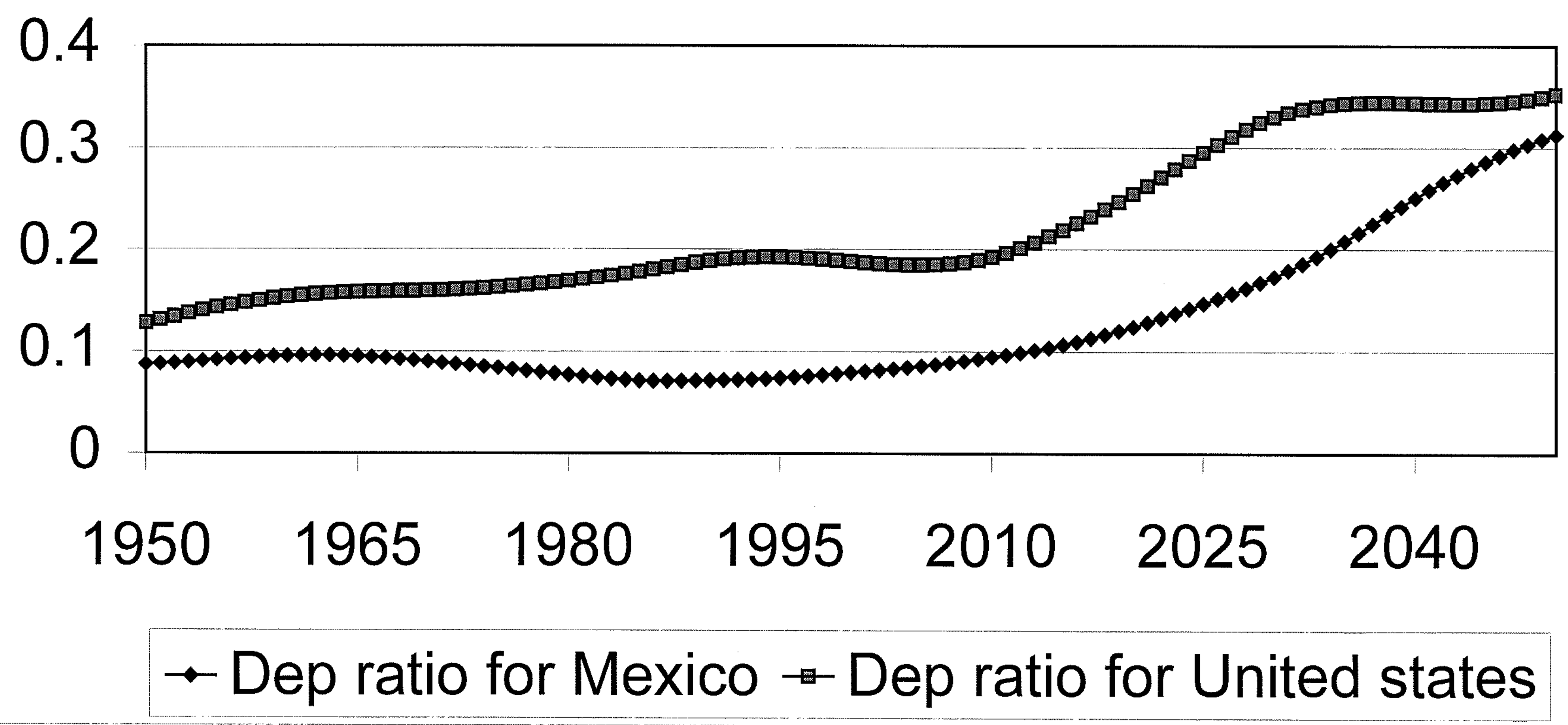
Over the next 35 years, in an increasing number of countries, post-war "baby boomers" are expected to retire, people to live longer and the fertility rates to decline. All these contribute to the population aging process. The proportion of the world's population that is 65 years old and over will nearly double, from the current 9 percent to 16 percent in 2035. For OECD countries, there are at the moment on average three workers to support one elder person, but by 2030 this ratio will become two to one. Although the aging process in the United States is less marked than the average for the OECD countries, it remains dramatic and hence the proportions of older people will increase substantially. According to the United Nations projection, when the first baby boomer will retire at 65 in 2011, the elderly will account for 13 percent of the total population in the U.S.. In 2029, when the last baby boomer reaches 65, fewer than 3 working people will support every older person, and the elderly population will reach 66.535 million in the

United States, that is about 20 percent of the anticipated total population (336.536 million). Most remarkable is that by the year 2030, the oldest old population (80 years old and over) in the United States will have doubled.

Mexico is also anticipated to great changes in the age structure. Population aged 0-14 years old will even decline from 32.1 million in 1990 to 30.1 million in 2025; Population aged 15-64 will increase from 48.8 million in 1990 to 87.9 million in 2025, and to 96.3 million in 2050; However the older population (aged 65 years old and above) will increase from 3.3 million in 1990 to 12.1 million in 2025, and to 27.4 million in 2050. In 2050, the elderly will accounts for 19.4 percent of the total population.

It is well-known that population aging is best described by the old dependency ratio (the ratio of population 65 years and older to those between the age of 15 and 64). This is because it indicates the level of economic pressure on the working population to support the retiree. The demography projection of these two countries is illustrated in Figure 1 .

## Figure 1
## Old-Age Dependency Ratios for Mexico and the United States



The aging processes of the two countries are different with respect to the size of the old dependency ratio and to the pattern of the aging process. In the United States, the dependency ratio increased between 1950 and 1995, then decreased gradually until 2005, then go up for ever. For Mexico, the dependency ratio increased from 1950 to 1963, then decreased until 1987, after that, it increases again. The dependency ratio of the United States remains higher than that of Mexico over the entire horizon. The old dependency ratio of the United States will increase from 19.18 percent in 1996 to 29.49 percent in 2025, and to 35.24 percent in 2050. In Mexico, the dependency ratio will go from 7.44 percent in 1996 to 14.68 percent in 2025, and to 31.23 percent in 2050. The sources of the population aging procedure are, however, different between the United States and Mexico. In the U.S., the continued population aging results from two factors: the decline in the level of fertility after the baby boom in 1964, and increasing longevity, the main reason being the former. The baby boom generations (born during the late 1940s and the early 1950s) are getting older and older, and will start retiring in and after 2010. In Mexico, there is no demographic shock caused by the so-called "baby boom". The main reason of the aging population process stems from the population policy focusing on family planning (initiated in the 1970s) and the better health and higher living standards, declined mortality rates for Mexicans. As we know, population aging caused by declining level of fertility and declining level of mortality have different economic impacts. One difference is that the number of children who need to be supported is reduced if the level of fertility decrease, while it will not change because of the increased longevity. Of course, a reduction in the burden of children may compensate some increased burden of the elderly people. Another important difference between these two factors is that falling level of fertility tends to slow down the growth of the labor force, but the decreased mortality does not. The falling growth of labor force makes it very difficult to offset large increased in saving without augmenting the capital-labor ratio, and hence reducing the rate of return to capital.

## IV. Macroeconomic Issues Related to Aging Population

Population aging is somewhat good news as it implies that more and more people will live longer and healthier. Moreover, old people possess wisdom and experience they can transmit to young people. However, population aging also implies that the working age population will need to support more old people who are no longer economically productive. Therefore a higher dependency ratio may put powerful pressures upon many aspects, such as reducing public savings, increasing the portion of consumption in GDP, declining labor supply, changing capital flows, investments, wage rates and capital labor ratios.

Population aging may lead to large increase of public debt over the period 1995 to 2030. The International Monetary Fund, the European commission and the OECD Secretariat all conclude that projected pension benefit levels will be greatly larger than projected payroll tax receipts in most countries, leading to large increases in deficits in pension accounts and in public finances, unless pension programs are reformed.[1] Also if no reforms are conducted, public expenditure on pensions in many OECD countries would increase by 5 per cent of GDP and the tax burden would rise by the same amount.[2] Population aging may also cut the productivity growth rate by reducing labor supply and hence threatening living standards. Population aging has impacts on the international

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1, 2: DRAFT REPORT TO MINISTERS ON AGEING POPULATION GENERAL BACKGROUND PAPER of " MAINAINING PROSPERITY IN AN AGEING SOCIETY", OECD.

capital markets, too. Because the demographic changes will lead to economic adjustments, the aging of populations will have important implications for current balances and international flows of goods, services and capital, and exchange rates, and hence may cause imbalances in savings and investments. Without doubt, the endogenous changes in the international flows of goods and capital will change net foreign assets, further affecting the current account balances of individual countries.

I can expect that the difference of the demographic projections between the United States and Mexico disturb trade and capital flows between the two countries, and hence affect the current account balances and the macroeconomic performance. Put it in another words, being a much larger economy, the effects of the demographic shock in the United States could be transmitted to Mexico by trade and capital flows. At the global level, net changes of current account balances in individual country must sum to zero, so it is not the absolute aging that determine the effects on current balances but the speed of aging of a given country relative to its trading partners. In this paper, I investigate the impact of population aging on the current account balances of Mexico by treating Mexico as a small open economy.

## V. Literature Review on OLG Models and Aging

There exists a broad literature on the economic consequences of population aging. However there is no agreement on what the scale of the economic effects of demographic change will be. Modigliani and Brumberg(1954) using the standard life cycle model, suggest a strong link between private saving and the age structure of the population. Meanwhile, aggregate time-series data studying the relation between saving rates and demographic composition confirmed the life cycle prediction: Saving rates tend to be lower in countries where population aging is more pronounced (Modigliani,1970);. But some evidences at micro level do not support the prediction of simple life cycle models Kotlikoff and Summers (1981) conclude in their paper that life cycle saving only explains a small part of observed shock of wealth of the economy. But there is also some evidence, which is consistent with the life cycle behavior. David N. Weil(1994) investigates the source of the difference between estimates of the saving of the elderly in micro and macro data. He concludes that one can not test life-cycle model using micro or macro data but can forecast the impact on saving of the demographic change by using macro data because macro estimates cover not only individuals' own saving but also their effects on the saving of others.

David Miles (1999) builds a calibrated general equilibrium models to assess the impact of aging on pension systems. He explains that household data do not demonstrate lower saving rates in retirement than during working period because there is a divergence between behavior implied by the model and micro data on household wealth accumulation. He also use the model to do some simulations of the shifts of the public pensions and tax rates caused by the demographic change. He concludes in his study: private savings highly depend on age. Savings in the long run are likely to fall significantly below recent levels because of the increased proportion of elderly people. However the impact of falling saving on the return to capital will not be large because a lower saving rate will be compensated by a declining volume of the work force.

Matthew Higgins (1998), discusses the relationship among age structure, national savings and the current account balance. He performs an econometric study by using time-series and cross-section data for 100 countries. He investigates the effects of the marked demographic changes in the decades to come upon national savings, investment rates, and also the speed of capital formation. His conclusions are that the increased youth and elder dependency ratios drop down the savings rate. This effects on national savings rates are very large, over seven percent of GDP in the last decades for many countries. He also points out that population aging has significant effects on savings supply and investment demand, further affecting net capital flows or the current account balance. He estimates this effect goes above four percent of GDP for many countries.

Cutler, David M, et al.(1999) uses the United States as an example to discuss whether a nation would raise or lower its saving rate while facing the upcoming demographic change. They argue that holding other variables constant, forthcoming demographic changes will reduce national saving. The investments need will also decline because of a decreased proportion of children of the population and slower growth of the working people resulted from the falling fertility. Therefore the rising elder dependency burden will be alleviated.

The interaction between two countries in a life cycle framework has been investigated only by a few researchers. Buiter (1981) extends a Samuelson-Diamond overlapping generation model to a two-country framework. He assumes the only difference between these two countries is their pure rate of time preference. Individuals tend to maximize their total utility discounted by their rate of time preference. He concludes that in the steady state, the country with the higher pure rate of time preference (people are less patient) has a lower supply of savings and run a current account deficit. He also shows the young generation in the country in which people are less patient has a lower welfare under openness than under a closed frame, whereas for the country with more patient people, the conclusion is the contrary .

Turalay Kenc and Serdar Sayan (1999) argue that international trade (including commodity and capital flows) and interest rates help to transmit the demographic effects from large countries to small countries. They use an overlapping generation computable general equilibrium model to study the economic effect on Turkey of Turkey's own demographic change and the population aging in Europe. The simulation results show that population aging and age structure changes caused by demographic transition will affect the time paths of many macroeconomic indicators significantly and that aging shock in Europe is going to reinforce these effects. These effects include the effects on investment, household savings, consumption, labor supply, exchange rate, wage rate and interest rate. Savings and investment in Turkish economy are expected to increase until 2010, but due to the transmission effects of the aging shock in Europe, they will declined between 2020 and 2150, and so will be real consumption and output. Between 2010 and 2150, the transmission of the aging shock in Europe will increase the wage rate more than unique Turkey's own demographic change. They think demographic effects are transmitted to other countries through the changes in interest rates in major suppliers of foreign capital to the rest of the world. They also conclude that this transmission effects will cause a greater increase in the capital-labor ratio. Therefore, they advocate Turkish policy makers to watch closely the demographic changes occurring in Europe. One of the questions that this paper attempts to respond is if the case of Mexico and the United States is similar to that of Turkey and Europe.

## VI. The model

The model used in this paper is a dynamic computable overlapping generations (OLG) model under a small open economy context. The model was developed by Fougère and Mérette (1998). In this paper, I try to investigate the possible effects of population aging in the United States on the current account balance of Mexico.The computable OLG model is solved using an algorithm written in the programming language GAMS.

Mexico is considered as a small open economy relative to the United States. A small open economy means that the capital market adjust through international capital flow instead of changes in domestic capital return in a closed economy. Therefore the interest rate movements of Mexico are assumed to be determined by the capital market developments of the U.S. The Fougère and Mérette's models assume that savings behaviour follows life-cycle theory. For the model, 15 generations are living side by side.To reduce the computational burden,we assume that each generation has 15 time periods to live, with each period equal to 4 years. Each person is assumed to have an economic life of 60 years, becoming active at age 16 and dying at age 75. The retirement age is assumed to be 63. Thus the first twelve generations are working generations, known as active population. The last three generations are called the retired generation. The population growth rates are exogenous in the models. As Fougère and Mérette say in their paper(1999) : the model is of the type first developed by Auerbach and Kotlikoff (1987). The models are composed of three main sectors: the firm sector; the household sector; and the government sector. Firms hire labor and rent capital to maximize their profits subject to a technology constraint. Households supply exogenous labor and maximize their utility which is composed of bequests and consumptions. As to the government sector, it balances the budget every period.The models also assume that in the very long run, population remains constant and the general equilibrium of the model is determined by steady state population. Based on these assumptions, the models try to solve the pattern of savings, government expenditure, interest rates and other variables of the economy following a demographic shock.

In the following, I describe the models more precisely.

*Firm Sector*

The production function used in the model has a Cobb-Douglas form, which depends on physical capital and labor:

(1) $Y_t = \theta K_t^{\alpha} N_{e,t}^{1-\alpha}$ ,

In this equation, $Y$ is firm's final output, θ is the technology factor, $K$ is the stock of physical capital, $N_{e,t}^{1-\alpha}$ is the effective labor force at period t and α referred to the share of capital. I calculate α as the average of share of capital of the private sector and public sector.[3] Given the OLG structure, we need to distinguish the life-cycle productivity pattern between an individual from the productivity level of a cohort.

We assume that the productivity of a worker is represented by a quadratic function:

(2) $efp^g = \gamma + \mu g - \varphi g^2$ , $\gamma$, $\mu$, and $\varphi > 0$.

In eq(2), $\gamma$ , $\mu$, $\varphi$ are all human capital productivity parameters. $g$ is the age of working population. The eq(2) means that with approporiate parameter value, the productivity of a worker increases until middle-age and then declines.

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3 The share values are stated in the calibration section, See Table 4 and Table 5.

The productivity across cohorts is represented by the following equation:

(3) $ne^{g+1} = (1/te)ne^{g}$ ,

where *ne* is the productivity level of a typical cohort, as we can see from eq (3), each new cohort (g) is more productive than its predecessors (g+1) by a constant factor of technical change (greater than one). Therefore, both the technical change and the growth of the working age population increase the effective labor supply. Thus the effective labor supply at period *t* can be written in a summation form:

(4) $$N_{e,t} = \sum_{g=1}^{12} efp^{g} \eta_t^{g} pop_t^{g}$$

Where $efp^{g} \eta_t^{g}$ is the effective productivity of generation g at period t and $pop_t^{g}$ is the population of age g at period t.

To solve the programming problem of the firms, we need to start from the final goal of the firms which is to maximize profits. That means the market rental rate and the market wage rate per unit of effective labor would be kept at the levels where firms' marginal products and marginal costs are equal.

(5) $$r_t - \delta = \alpha\theta K_t^{\alpha-1} N_{e,t}^{1-\alpha}$$

(6) $$\omega_t = (1-\alpha)\theta K_t^{\alpha} N_{e,t}^{1-\alpha}$$

In eq (5), $r$ is the market capital rental rate, $\delta$ is the capital depreciation rate. In eq (6), $\omega$ is the market wage rate.

*Household Sector*

Aggregate consumption, saving and labor supply all follow the intertemporal optimizing behavior of forward-looking individual household. Individual maximizes his utility function U, which is a constant inter-temporal elasticity of substitution utility function.

(7) $$U = \frac{1}{1-\phi}\sum_{g=1}^{15}\left(\frac{1}{1-\rho}\right)^{g}\left(C_{g}^{1-\phi} + \beta_{g}^{\phi} Beq_{g}^{1-\phi}\right), \quad 0<\phi<1;\ \beta_{g+15}=0;\ \beta_{g15}>0,$$

where $\phi$ is the inverse of the intemporal elasticity of substitution, $\rho$ is the pure rate of time preference, $\beta$ is a constant bequest parameter and *Beq* are bequests. As is argued by Fougère and Mérette (1998), bequests in the utility function are specified as in Blinder (1974). It is also assumed that all working generations receive equal bequests from the generation who is at its last period of lifetime. Disposable income (*dic*) is determined by the following equation:

(8) $$dic = \omega_t efp_t^{g}(1-\tau_{\omega,t}) + rha_t^{g}(1-\tau_{k,t}) - \tau_c C_t + pen_t^{m}(1-\tau_w),$$

where *ha* is household assets; $\tau_w$, $\tau_k$ and $\tau_c$ represent wage rates, capital income rates and consumption rates respectively; $pen_t$ are pensions. Therefore, the budget constraint of the individual at a given generation at period can be written as:

(9) $$ha_{t+1}^{g+1} - ha_t^{g} \le \omega_t efp_t^{g}\eta_t^{g}(1-\tau_{w,t}) + r_t ha_t(1-\tau_k) - (1+\tau_c)C_t + \omega br(1-\tau_{w,t}) - Beq_t + Inh_t$$

The left expression ( $ha_{t+1}^{g+1} - ha_t^g$ ) equals private savings, $Inh_t$ is inheritance, which are assumed to be distributed equally among the 12 working generations in the following way:

(10) $Inh_t^j pop_t^j = \frac{1}{12} Beq_t^m pop_t^m$ , j=1,2, and m=15.

The pensions are defined by the following equations:

(11) $pen_t^m = \varphi \frac{1}{12} \sum_{g=1}^{12} \omega_{t-m+g} ep^g \eta_{t-m+g}^g$ , m=13,14,15.

φ is a fraction. Eq(11) states thate pensions benefits of an indivisual are a fraction of the avarage salaries during his working life.

*Government Sector*

The government budget constraint is:

(12) $D_{t+1} - D_t = r_t D_t + G_t + PEN_t - T_t$ ,

In the model, the pension system is assumed to be pure " pay-as-you-go" ( PAYG ) and financed by general tax revenue. Thus $PEN_t$ is the total pensions payments. ( $PEN = \Sigma pop^g pen^g$ ) of all generations; $D$, $G$, $T$ are government bonds, government expenditures and government taxes respectively. There are three kinds of taxes collected by government: wage income tax, capital income tax rate and consumption rate. Among them, the capital income tax rate and consumption tax rates are constants, hence the wage income tax rate adjusts to balance the budget. The government issues one period bonds. The total government revenue is given by

(13) $T_t = \tau_{w,t} \sum_g (\omega_t efp^g n_t^g + pen_t^g) pop_t^g + \tau_k r_t \sum_g a_{k,t}^g \cdot pop_t^g + \tau_c \sum_g c_t^g \cdot pop_t^g$ .

$T_t$ is the total government revenue and $a_{k,t}^{g}$ is the capital assets.

*Aggregate and Equilibrium Conditions*

In every period, the labor market, the capital market, and the goods market are all in equilibrium. In steady state, price and macroeconomic ratios are constant.

We now contrast the equilibrium condition for the capital market and the goods market in a closed economy with that in a small open economy. In a closed economy, the sum of the physical capital and government debt equals to the total household assets:

$$(14) \qquad K_t + D_t = \sum_g a_t^g \cdot pop_t^g$$

While in a small open economy, the equilibrium condition changes to:

$$(15) \qquad K_t + D_t = \sum_g a_t^g \cdot pop_t^g + NFD_t$$

Where $NFD_t$ is the stock of net foreign debt.

For the goods market, the aggregate equilibrium conditions for a closed economy and an open economy are:

$$(16) \qquad Y_t = C_t + G_t + I_t^g \qquad \text{(closed economy)}$$

$$(17) \qquad Y_t = C_t + G_t + I_t^g + \text{NEX}_t \quad \text{(open economy)}$$

where total consumption $C_t = \sum_g c_t^g \, pop_t^g$ , $G_t$ is total government expenditure, and $I_t^N = K_{t+1} - (1-\delta)K_t$, the current account balance $NEX_t = -(NFD_{t-1} - NFD_t - r_t NFD_t)$

## VII. Calibration

In the calibration model, I assume that in 1950, the economies are in the steady state, which is to say, some parameters such as the population, productivity growth rate, physical capital, tax rates, savings rates are all fixed. Even though there may be differences in some utility and production function parameters between Mexico and the U. S. in reality, it is impossible to get any precise information on the actual differences. So in this model, we also assume some common parameters for Mexico and the United States as Fougère and Mérette (1999). For instance, the inter-temporal elasticity of substitution ($1/\phi$) and the productivity of human capital parameters ($\gamma$, $\lambda$, $\varphi$) are identical in both countries.

In my calibration model for Mexico, I keep most values of the parameters the same as in Fougère and Mérette (1999) did in their paper and only change the share of capital in production funtion, the three tax rates and the return to capital. The share of capital in the production function is calculated from the data as the average of the share of capital in private production and that in government production, and the share of capital in private function is an arithmatic average of the six private sectors as defined in Andrew Feltenstein and Jiming Ha (1999). I also assume the wage-income tax rate equals to the capital income tax rate and both of them equal to the avarage of the percentage of the tax revenues between 1983 and 1985. The consumption tax rate is assumed to be zero. As to the interest rate, to keep consistency, I take the average of the real interests from 1993 to

1985. To fit the elderly dependency ratios projection in 1952 of the United Nations, I also choose the initial population growth rate to be 1.35 percent. In the following simulation section, I am going to start with this initial population growth rate and change it to simulate the demographic shock.

Table 1 and Table 2 in the appendix summarize the values of the parameters used in the model. Table 3 summarizes the utility and production function parameters which are selected through a large number of studies. Table 4 and Table 5 show the basic Mexican data.

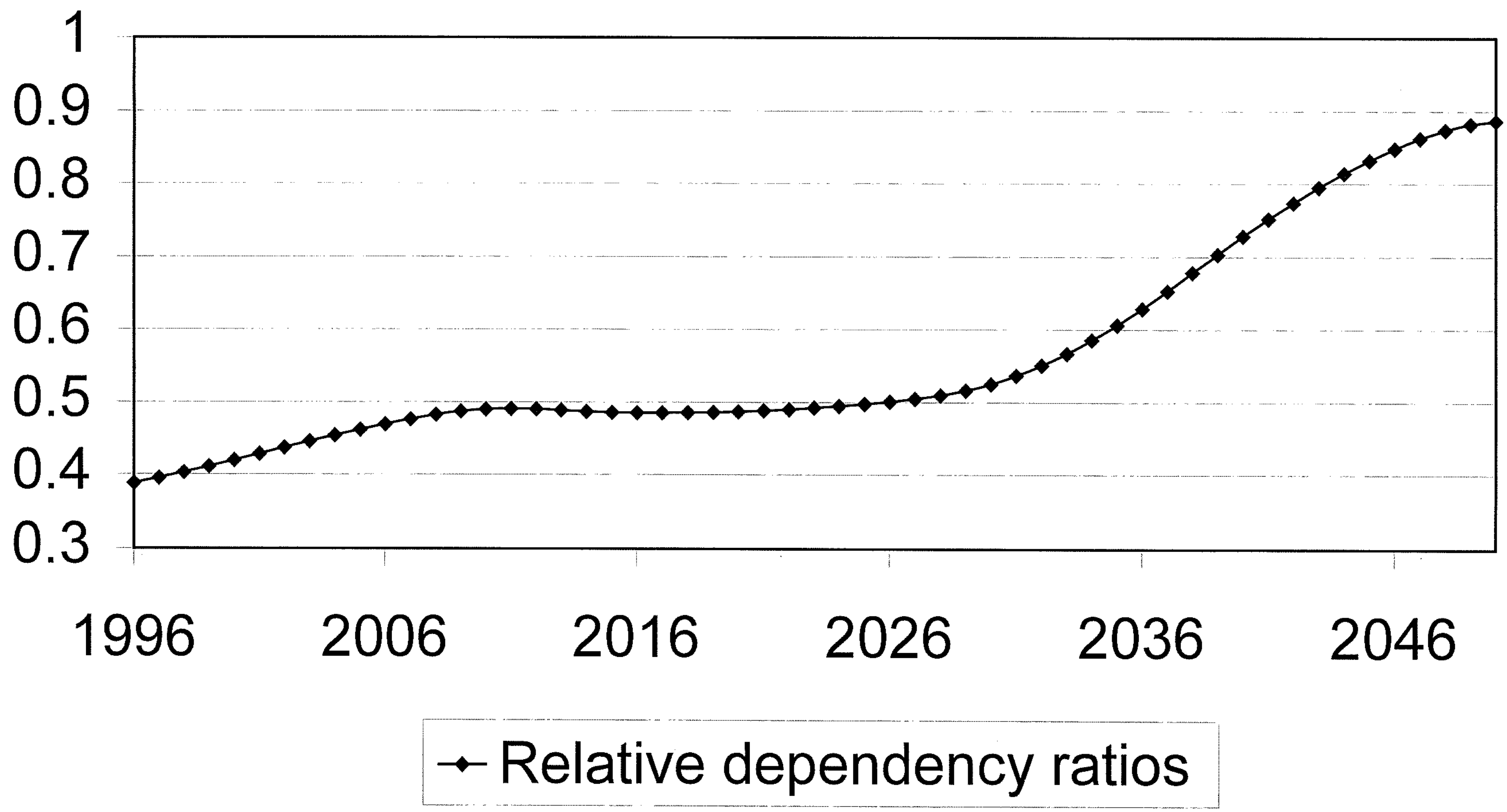
## VIII. Simulation Results

In the description of the model, I have demonstrated that one aggregate equilibrium condition in the open economy is that the physical capital stock plus government bonds must equal the sum of the households assets and the foreign debt. Under a small open economy assumption, the movements of the interest rates of Mexico are totally determined in the model by those of the U.S.. The dynamic path of interest rate for U.S.were taken from Fougère and Mérette (1998) who simulate the aging shock for the U.S. economy. Therefore the trend of the current account balances of Mexico is highly correlated with its aging shock relative to that in the U.S..

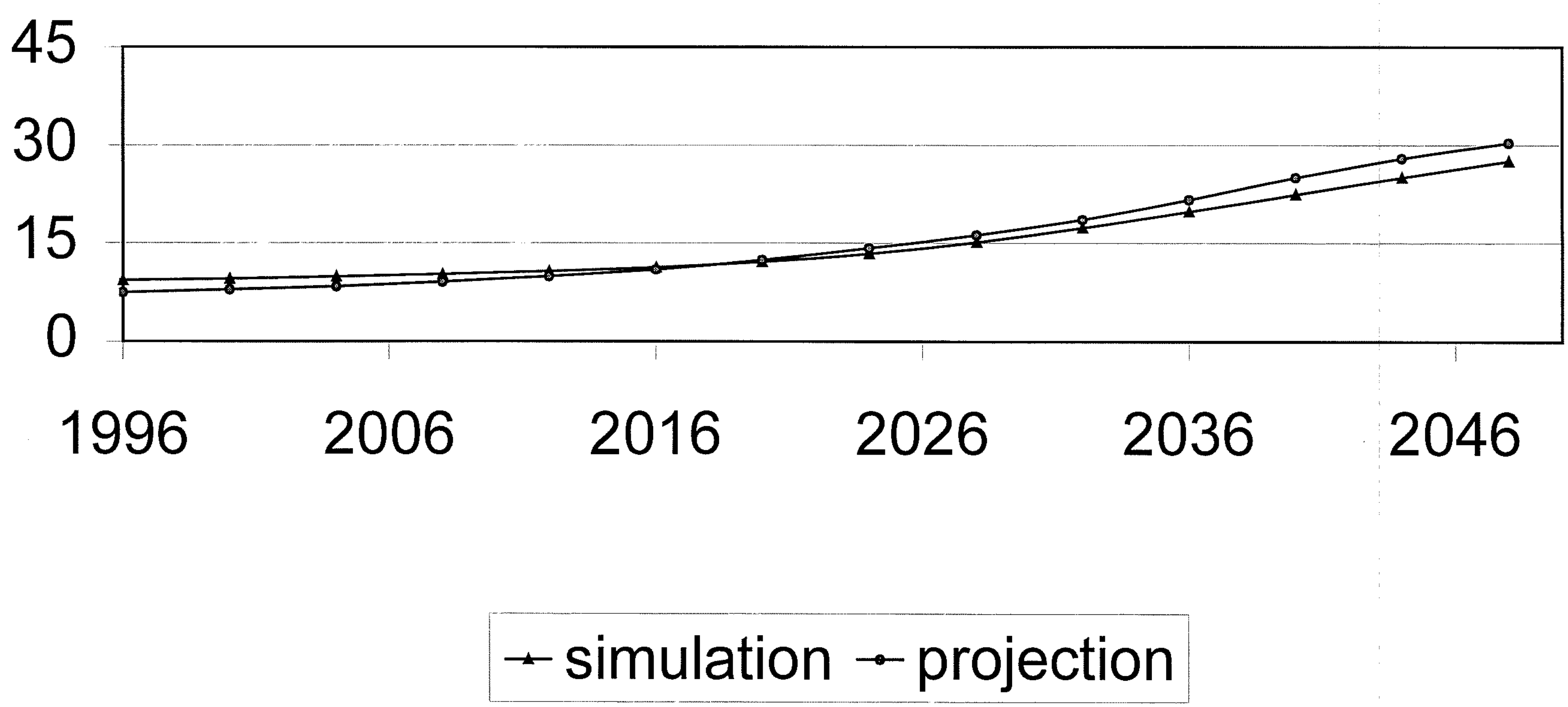
Figure 2 displays the relative dependency ratio between Mexico and the United States from 1996 to 2050 . As we can see from the Figure 2, the relative dependency ratio between Mexico and the United States changes a lot over time. It is around 0.38 in 1996, after that it increases all the time, to finally move up to 0.88 in 2050. This increase in the relative dependency ratio figure shows that the aging process in Mexico is more rapid than that in the United States. As we discussed before, how much the current account balance would be affected depends on the process of population aging of one country relative to the another. The demographic shock may change the international capital flows between countries through the changes in the world savings and investments, to further affect current account balances.

By changing the birth rate, I simulate the demographic shock which began in 1956. By stating so early, I can replicate the birth rate patterns that lead to the current and future demographic composition of the population. I assume that the birth rate decreased from 1956, from 1976, the birth rate began to rise, and after 1984, it began to decline again. In the model, I also assume that the birth rate goes to a steady state in the long run, as in Hviding and Mérette (1998). Accordingly, the old dependency ratio will change oppositely. Figure 3 displays the comparison of the simulation result and the United Nations projection of Mexican dependency ratios from 1996 to 2050. Figure 4 displays my simulation result for the dependency ratio for Mexico from 1996 to 2100. From the simulation, we find the dependency ratio will increase until around 2070, after that it will decline and become constants after a period of decline.

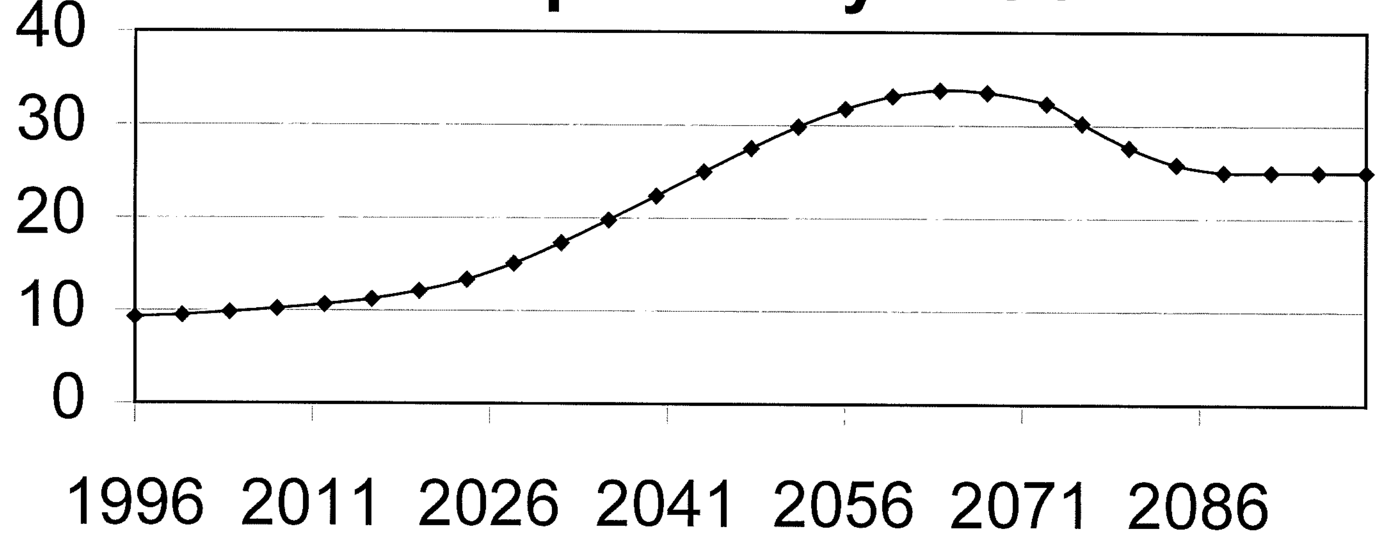
## Figure 2
## Relative dependency ratios between Mexico and the United States



## Figure 3
## Comparision between simulation and projection of old-age dependency ratio(Mexico)

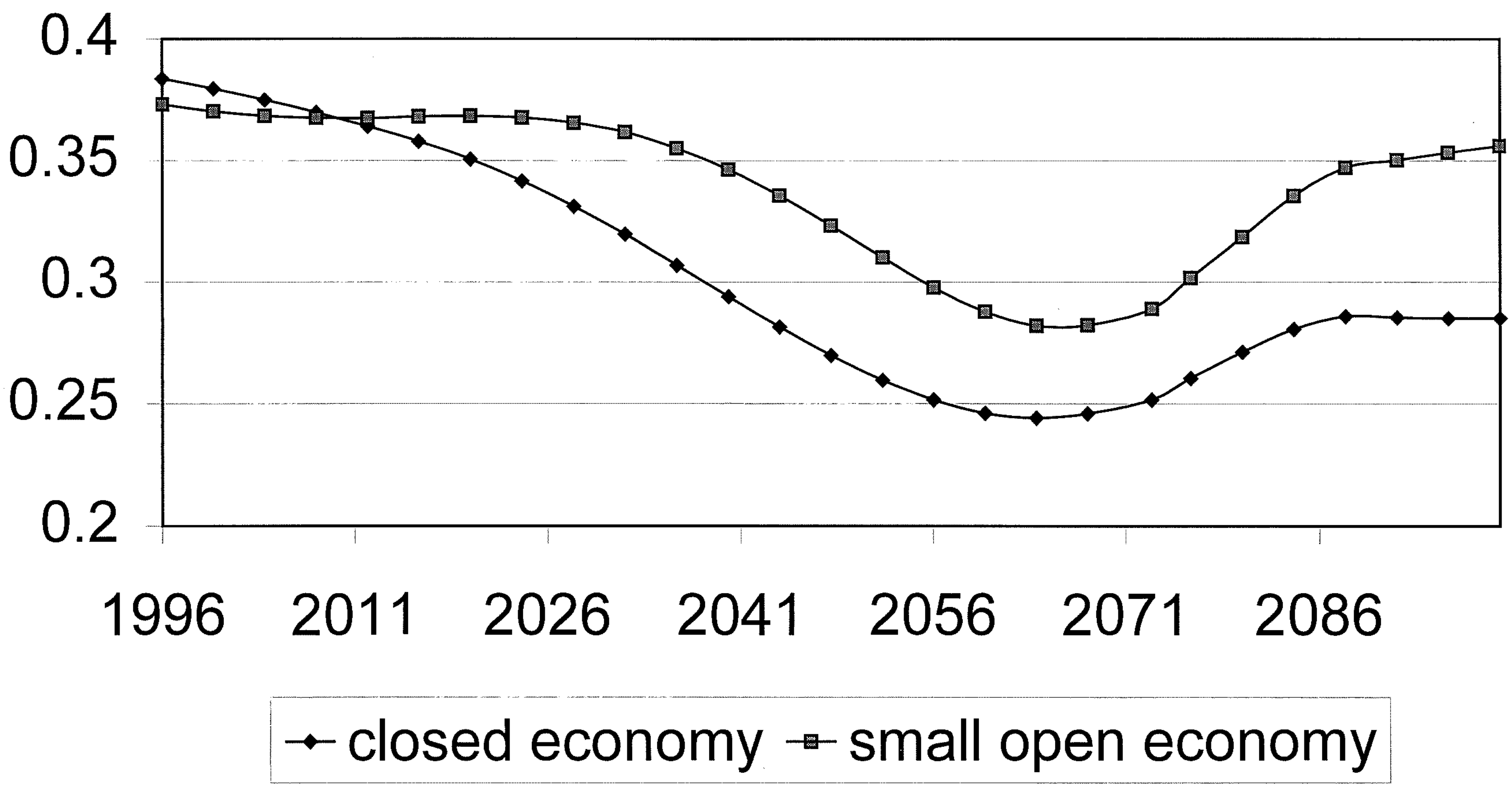


## Figure 4
## Simulation of Mexican Old-Age Dependency Ratio



As I introduced before, the current account balance of a small open economy is highly related to its aging process relative to its trade partners. Because the movement of the real interest rate of Mexico, under a small open economy assumption, is determined by the movement of the real interest rate of the U.S., to study the impact of the population aging shock on the current account balance of Mexico, we need to take a look at the impact of the demographic shock on the real interest rate (in steady state, the real interest rate equals to the real return on capital minus depreciation) of the United States. The trajectory of real return on capital of the U.S. is demonstrated in Figure 5. As we can see from Figure 5, in the U.S., the real return on capital changes dramatically. If there were no population aging shock, the real return on capital would stay constant. It was about 0.078 in 1996. From then on, it began to decrease, the lowest value of real return on capital is around 0.07 in 2028, after that, it goes up again until around 0.079 in 2100. The change in the real return on capital can be explained by the reduction in the labor supply, which results from the population aging shock in the United States.

## Figure 9
## Private Savings Rate (Mexico)



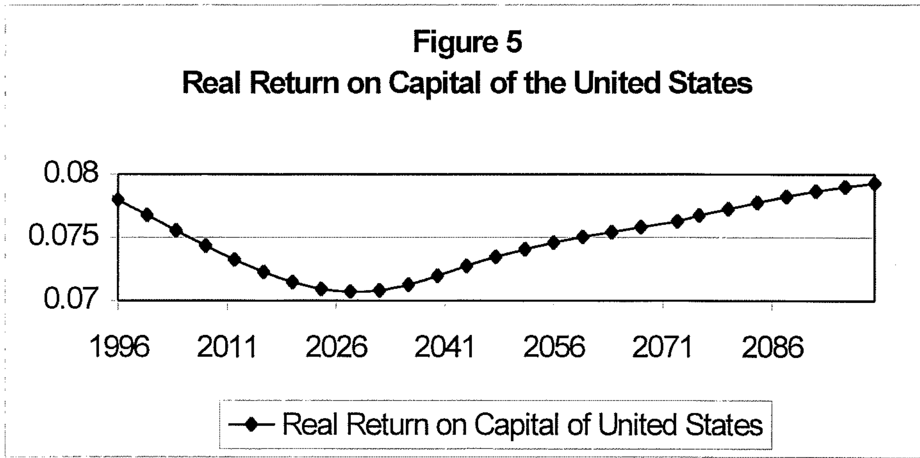
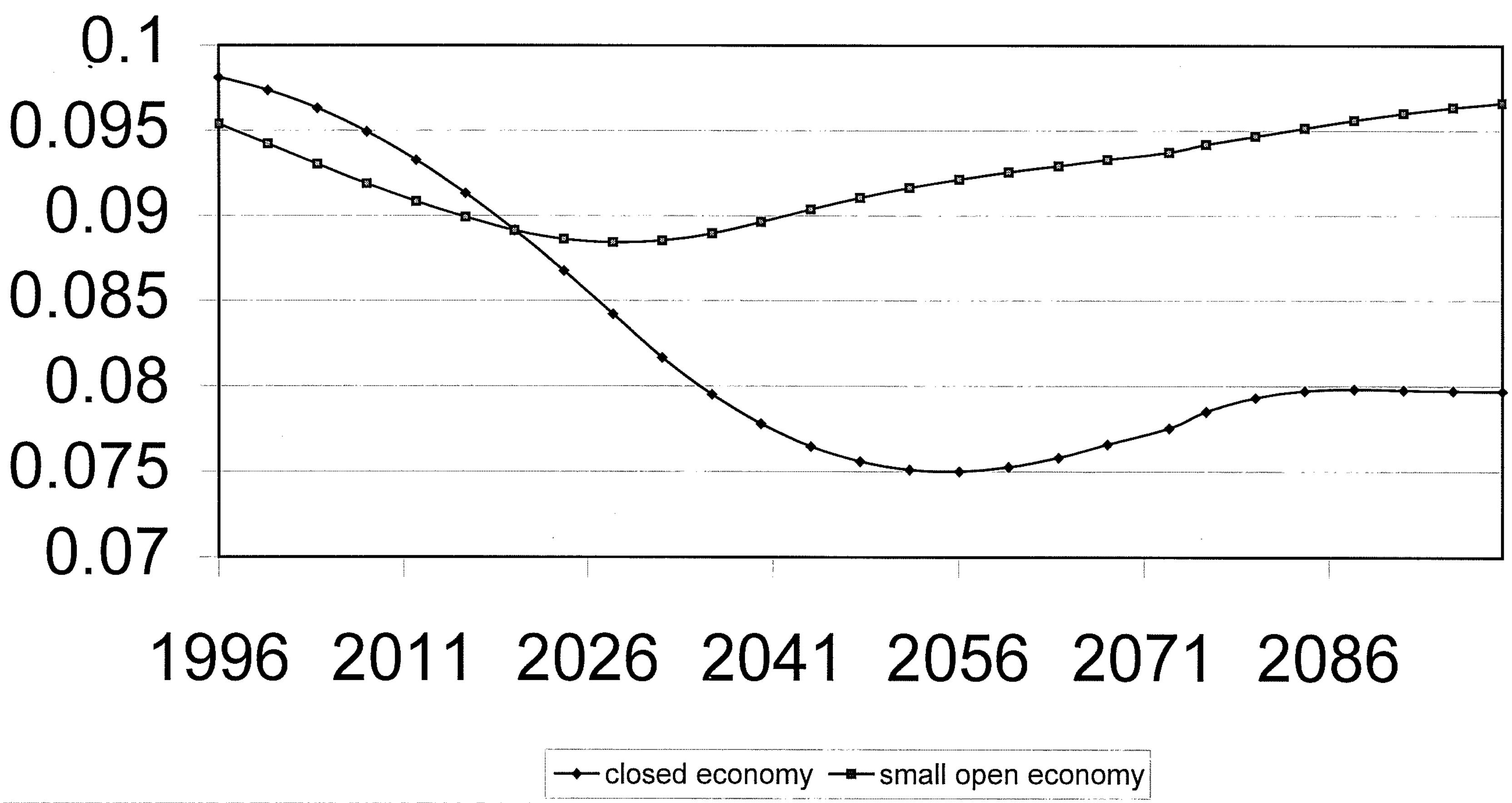



Figure 6 to Figure 13 show some simulation results of the demographic shock. The period covered goes down from 1996 to 2100, as beyond the economy is assumed to return to a steady state. The figures show how the demographic shock change savings, government expenditures, return to capital, wage tax rate, net foreign debt and real GNP per capita.

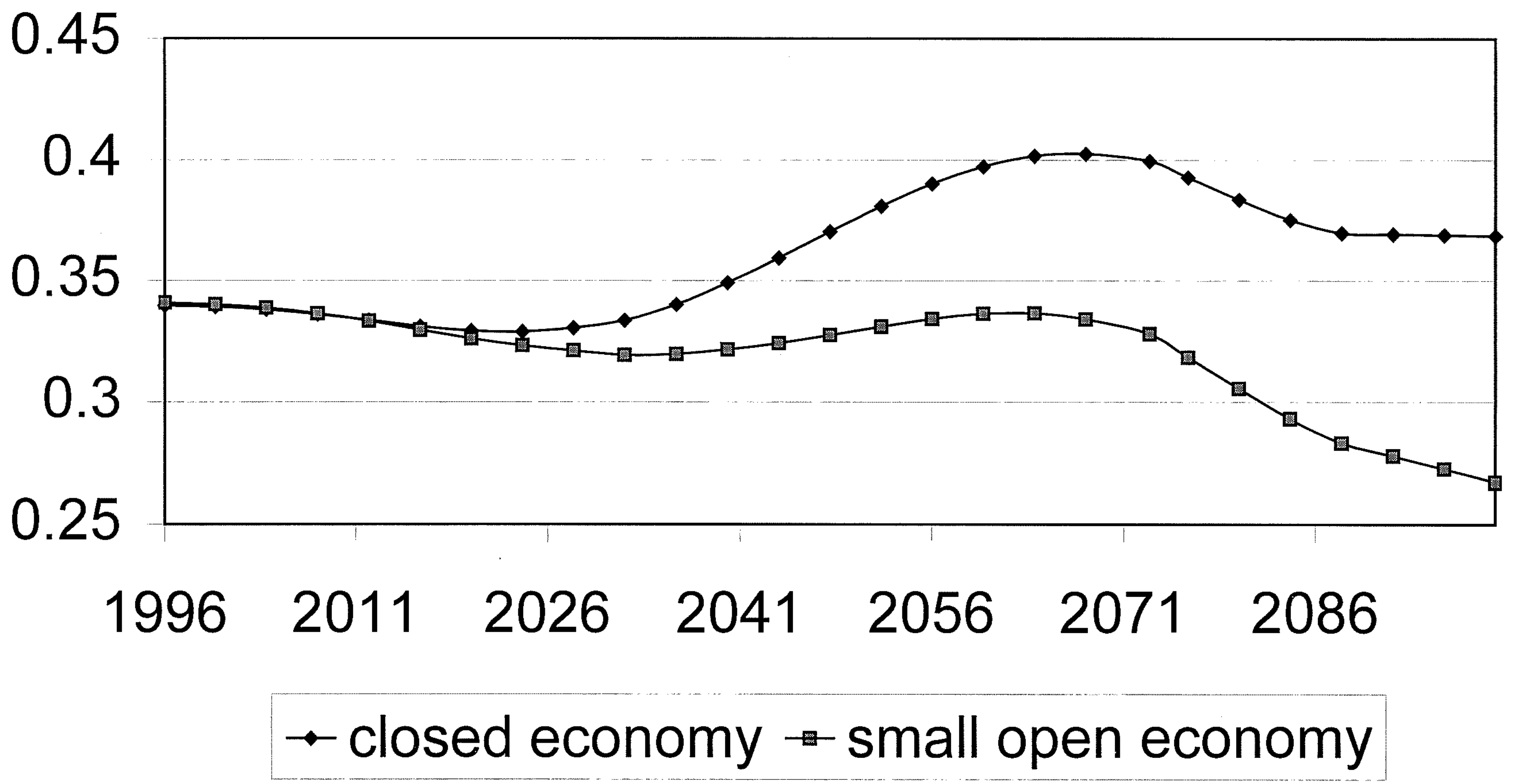
As Fougère and Mérette argue in their 1999 paper, the impact of the demographic shock on the current account balances depends on the difference in the real return on capital under the closed economy and the open economy. Here, we compare the impact of aging shock on the real return on capital in Mexico under both assumptions and the results are given in Figure 6. From that figure, I observe that the aging shock puts downward pressures on the real return on capital in both cases. In 1996, the real return under a closed economy is about 0.098, which is a little higher than that in a small open economy (it is around 0.095). At first, the real return on capital under both assumptions (closed economy and open economy) decline very slowly. Before 2020, the real return on capital in closed economy assumption is higher than that in the small open economy assumption. After that, the real return on capital under the small open economy assumption is much higher than that under the closed economy assumption. The real return on capital under the closed economy assumption declines to 0.075 in 2056, after that, it goes up, whereas that under the small open economy declines to 0.088 in 2032 and then goes up. In comparing the trajectory of the real return on capital under the small open economy context in Figure 6 with the real return on capital of the United States in Figure 5, we can find reasonable explanation. Because in a small open economy context, the movements of the interest rate of Mexico is determined by that of U.S., between 1996 and 2020, the real return on capital in the U.S. declined rapidly because of the demography shock, thus causing real return on capital in Mexico decline more than that in the closed economy. The closed economy means the real return on capital is only affected by the domestic demographic shock of Mexico. After 2020, the increase in real return on capital in U.S. leads that real return on capital under a small open economy assumption to be much higher than that under a closed economy assumption. This is probably due to the fact that after 2020, although population aging in Mexico remains less severe than in U.S., the process is, however, more rapid. The differences on real return under these two assumptions indicate the impact of the relative the population aging shock between Mexico and U.S., which will be reflected on the current account balances of Mexico.

## Figure 6
## Real Return on Capital (Mexico)



In the model, I have assumed the consumption tax rate and the capital income tax rate constants. It is the wage-income tax rate that restores the fiscal behavior. As we can see from Figure 7, in Mexico, the wage-income tax rate in an open economy context is close to that of the closed economy context in the first few years. After 2012, the wage tax rate under a small open economy assumption is lower than that under a closed economy assumption. To explain this, we need take a look at government expenditures and government revenue over GDP. Government expenditure in the closed economy and the open economy are shown in Figure 8. As we can see in Figure 8, the government expenditure over GDP under both assumptions are much the same. In the discussion about the real return under two assumptions, we have noticed that the real return under a small open economy assumption is higher than that under a closed economy assumption. This increases wealth returns and income in the private sector. The latter then pays more taxes as tax rate are proportional to income. Hence government revenue is higher under the open economy than under the closed economy. So after around 2012 the wage tax rates in an open economy is lower than that in a closed economy.

# Figure 7
# Wage Tax Rate (Mexico)



## Figure 8
## Government Expenditure Over GDP (Mexico)

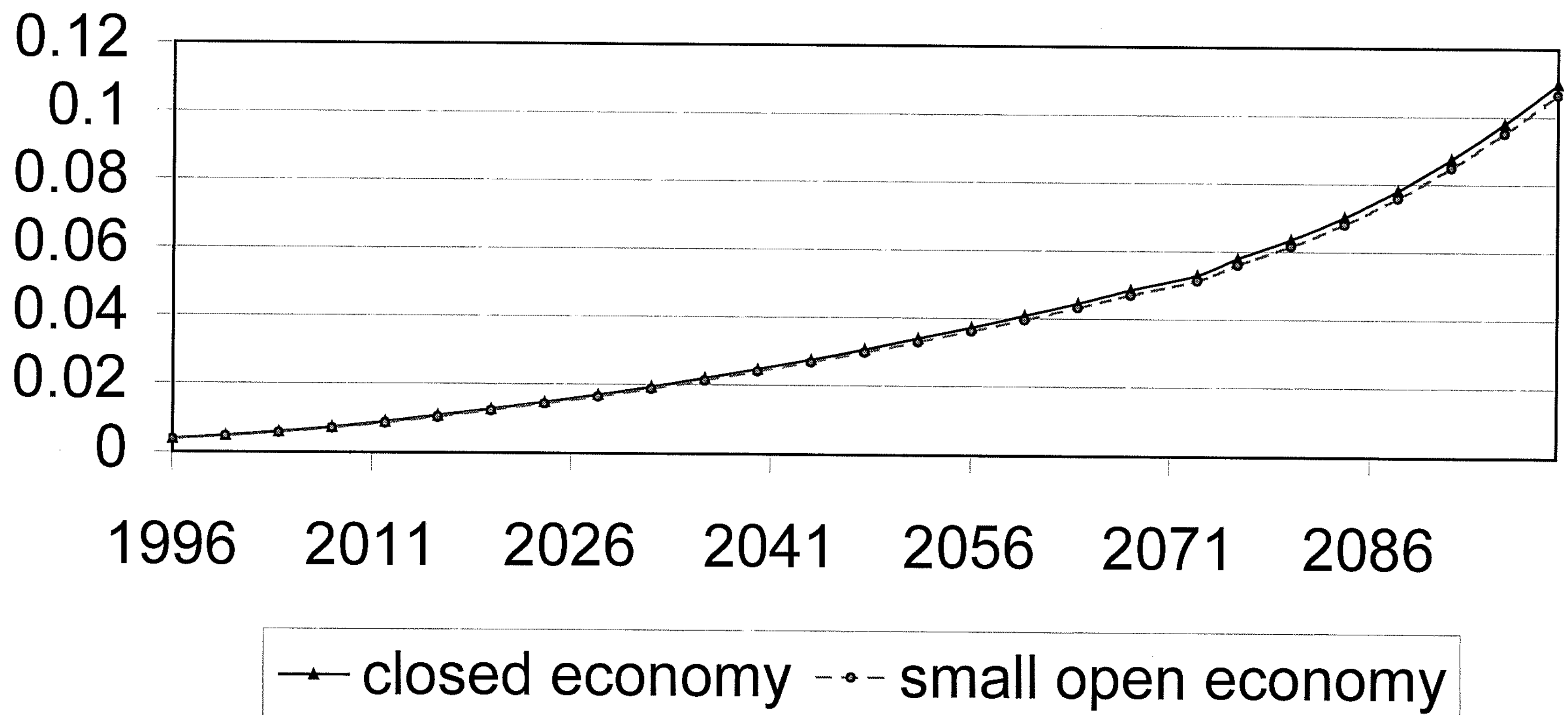
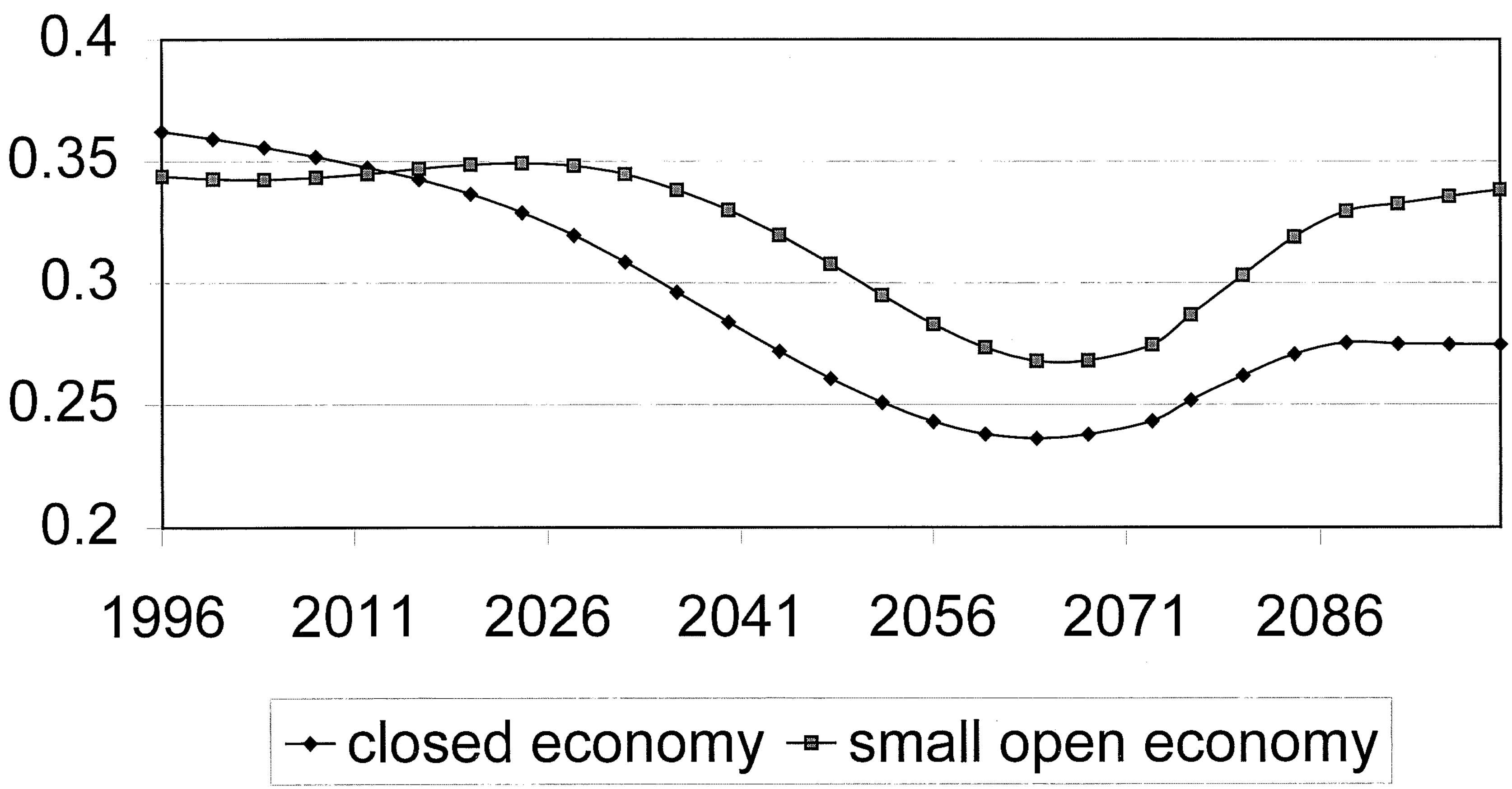


Figure 9 and Figure 10 display the trajectories of the savings patterns. Figure 9 is the trend of private savings rate in Mexico under both the closed economy assumption and the open economy assumption. As we can see from the figure, from 1996 to around 2064, the private savings rate under both assumptions decline. This is explained by the life-cycle hypothesis of a cohort behavior. From born to around 25 years old, it is the period of education, people in this period dissave. After that, until 65 years old, people save. After 65 years old, people get retired and they begin to dissave again. Population aging shock means an increasing proportion of old people (65 years old and over). So the private savings rate decline accordingly. As we can see from Figure 9, the national savings rate in the small open economy declines slower than that in the closed economy, this is related to the access to higher return for Mexican investors under the small open economy assumption.

For the national savings rate (see Figure 10), it is very similar to the profile of private savings rate. This is due to the assumption in the model that the government keeps debt-to-GDP ratio constant every period.

According to the equilibrium condition under the open economy consumption, the sum of domestic physical capital and the government debt equals to private wealth plus net foreign debt.

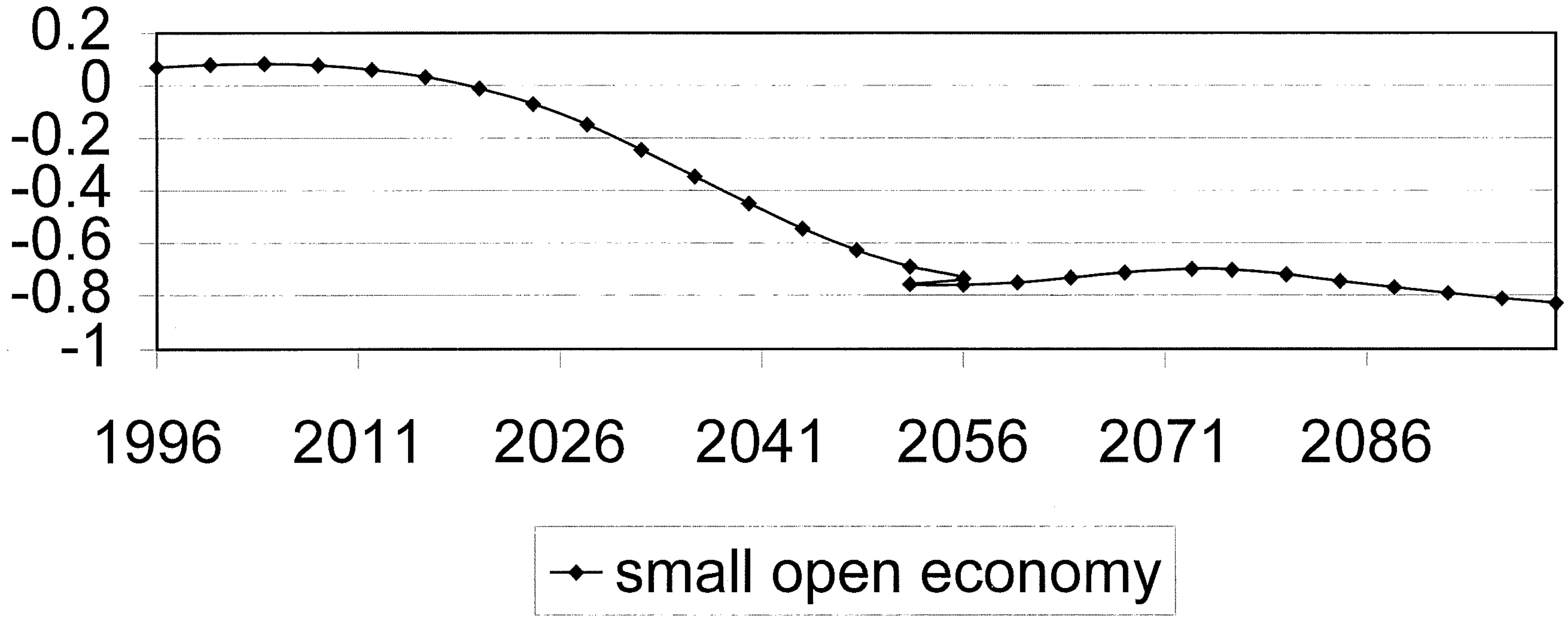
## Figure 10
## National Savings Rate (Mexico)



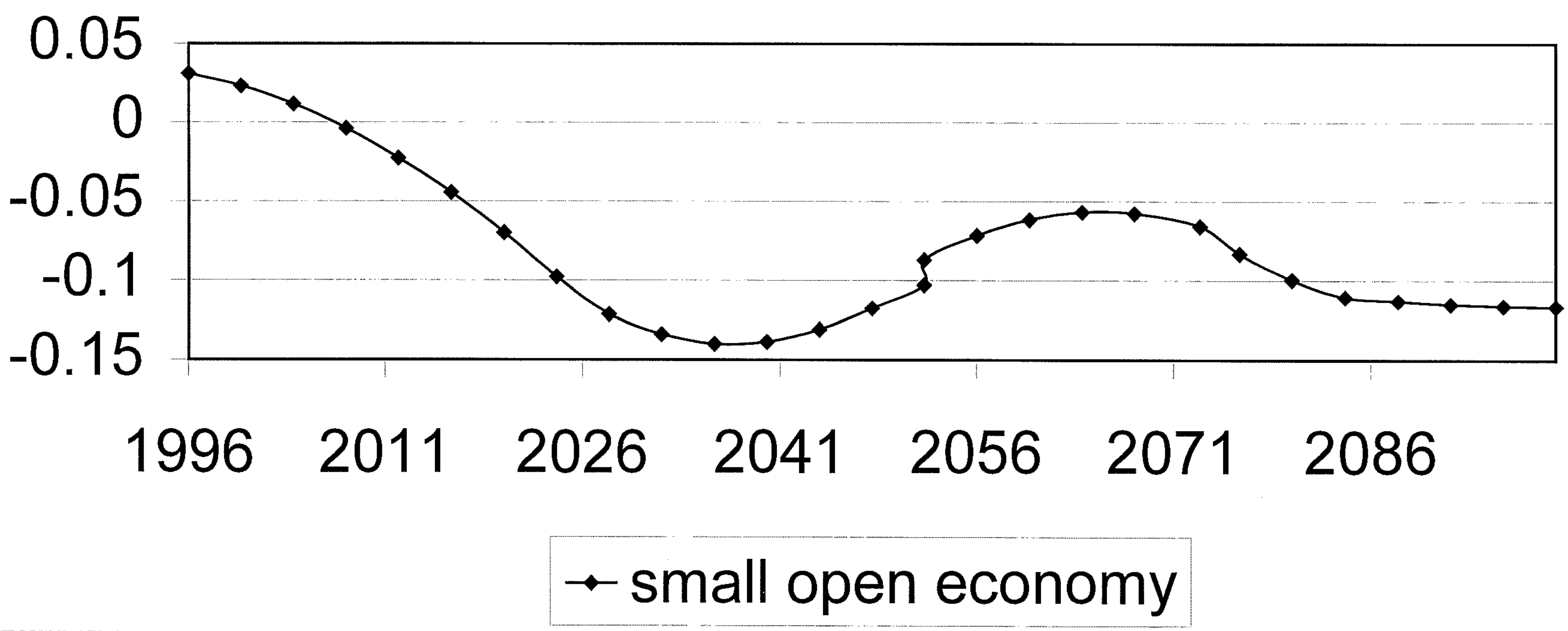
From Figure 11 (Stock of net foreign debt of Mexico), I find that the impact on the change in the stock of net foreign debt of Mexico is different from the cases of the six OECD countries that Fougère and Mérette analyze in their paper (1999). Here, the change in the stock of net foreign debt of Mexico declined first, then increases until around 2004, it reaches the highest level : 8.3 percent of GNP. After that, it will begin to decline again. Around 2020, it changes the sign from positive to negative. It continues to decline until around 2056, then increases for a short period, after that it declines again. As we discussed before, the impact of aging shock in the open economy context depends to a large degree on the relative ageing between the two countries. Therefore, the increase in the change in the stock of net foreign debt in the first few years are probably because the aging speed of Mexico is relatively slower than that of U.S. in those years, the capital exported to U.S. from Mexico is less than capital exported from U.S. to Mexico. Similarly, the decline of the change in the stock of net foreign debt over GNP is because the aging speed of Mexico is relatively slower than that of U.S. in those years. As Mexican benefit from higher rate of returns, they save and invest abroad more.

Figure 12 (net capital flows) tells us the impact of the aging shock of Mexico relative to the United States on the current account of Mexico. From Figure 12, we find between 1996 and around 2008, the relative dependency ratio between Mexico and the United States declines over time, thus causing a small net capital inflows, deteriorating the current account. In 1996, the current account deteriorates up to around 3.1 percent of GNP. After 2008, the relative dependency ratio increase over time, and I observe net capital outflow, which means a favorable impact on Mexican current account balances. In 2036, the current account is improved by13.99 percent of GNP relative to the no aging shock. Despite cycles, the relative speed of the aging shock between Mexico and U.S. is such that I observe net capital outflows thereafter.

## Figure 11
## Change in the Net Foreign Debt Over GNP
## (Shock minus control, Mexico)

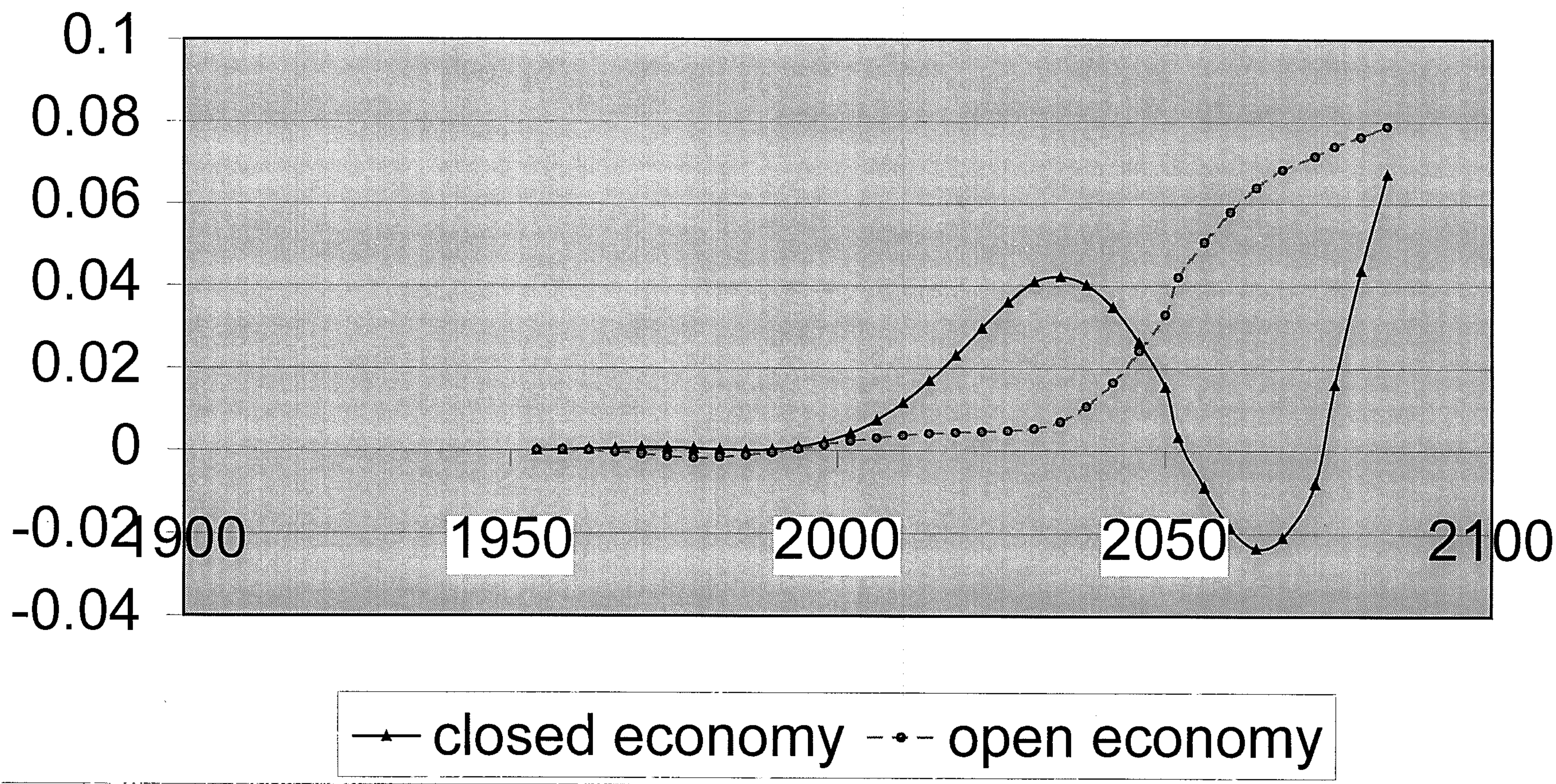


## Figure 12
## Change in Net Capital Flows as a Percentage of GNP
## (Shock minus control, Mexico)



In Figure 13, we compare the impact of aging shock on the real GNP per capita in both closed and open economy contexts. After about 2031, population aging shock will reduce the growth rate of real GNP under both assumptions. The negative impact of population aging on the real GNP is not hard to understand. It is well-known that the GNP growth of a country is equal to the work force growth times the productivity growth. If the productivity growth is slower than the declining rate of the work forces, GNP may decline. The point that the productivity growth in the future seems reasonable according to Peter G. Peterson (1999). He quotes William Baumol's conclusion that with the rising of the living standards, some services (such as teaching, medicine, entertainment) resistant to productivity improvement will increase as a larger part of the economy. As we know, the work force will decline because of the population aging. After 2031, there is a net capital outflows in current account balance. As a result, the negative impact on real GNP per capita of aging shock in a small open economy is less than that in a closed economy. This is consistent with the conclusion that Fougère and Mérette get in their paper(1999). The net capital outflows is probably because the impact on real GNP per capita of aging shock is not determined by the absolute levels of the old-age dependency ratios of Mexico and the United States but by the relative speed of growth rate of old-age dependency ratios of Mexico to the United States. As we can see from Figure 1, after about 2008, the speed of the growth rate of old-age dependency ratio in Mexico is higher than that in the United States. It is worthy to note that in the model, I do not include the human capital mobility. Under a more complete model (which includes the human capital mobility), outflow of capital could be accompanied by the export of Mexican human capital. As we all know, not only goods and services can be traded across border, but also labor can move across borders through immigration or other channels. The result of this human capital flow may cause a further decline in the work force of Mexico, further causing a negative impact on real GNP.

# Figure 13
# Real GNP per capita (Mecico)



## VIIII. Conclusion

In this paper, I have used Fougère and Mérette's OLG models of (1999) to analyze the impact of aging shock on the current account balances of Mexico and compare the impacts of aging shock under both the closed economy and open economy assumption. The parameters of the model are estimate by using Mexican data and data of previous research. Demographic projections for Mexico demonstrate that the population over 65 years old will account for a large proportion of the whole population in the next five decades, primarily due to the declining mortality rate and higher health care conditions. By changing the birth rate, we simulate the aging shock of Mexico. The old dependency ratio will continue increasing for a long period in Mexico before stabilizing. The United States is also experiencing the aging shock caused by the fertility shock of the late 1940s and the 1950s(so-called "baby boomers" keep getting older). The increasing older dependency ratio of Mexico will cause fluctuations of many microeconomic variables such as the private savings rate, national savings rate and government expenditure. What's more, Mexico, as a member of the NATFA, under the open economy assumption, is affected further by the transmission of the population aging pattern from the U.S. through the trade. From the study, I get similar conclusions to what Fougère and Mérette get in their paper(1999).

In a small open economy context, real return on capital of Mexico is larger than that in a closed economy because of the transmission of the demographic shock from U.S.. The wage tax rate under a small open economy assumption increases less rapidly than that under a closed economy assumption because of the change of real return under the two assumptions. This suggests lower pressure on the fiscal balance. National savings rate and private savings rate under a small open economy assumption are higher than those under a closed economy assumption. In a small open economy, the current account balances of one country depends on the relative aging development of one country to another. A relatively slower ageing country will suffer a deterioration in its current account balances(like Mexico before 2008). Similarly, when the aging process relatively faster, it implies an improvement in the current balance (Mexico after about 2008). Although the globalization of capital markets is reinforced by population aging and the result may improve the situation caused by domestic population aging for small open economies, Mexico, because of its relatively higher speed of the growth rate of old-age dependency ratio than that of the United States, the globalization of capital markets alleviate the negative effect of population aging on real GNP. This results confirm one of the conclusions of Fougère and Mérette (1999) : Under an open economy assumption, population ageing may cause international capital flows from countries where population aging more rapidly to contries with a relatively less old generations.(in this paper, it is from Mexico to the U.S.).

Because of the limits of time and knowledge, this paper only analyze the impact of relative population aging on the current account for one small open economy: Mexico. There is still a large space for studying the impact of population aging on international capital flows by using the OLG multi-country computational model. As global aging is a predictable certainty, research on this aspect will be of great importance.

## Acknowledgements

This major paper was done with the great help of my supervisor, Professor Marcel Mérette. His supervise and help I gratefully acknowledge. I wish to thank Professor

Marcel Mérette for his useful comments and technical teaching. Also, I want to thank Professor Gabriel Rodriguez for his helpful comments.

# Appendix

Table 1. Calibration results

| | $\alpha$ | $\delta$ | $\theta$ | $\rho$ | K/Y |
|---|---|---|---|---|---|
| Mexico | 20.4 | 2.85 | 1.12 | -0.07 | 6.3 |
| United States | 32.6 | 3.52 | 2.4 | 0.0055 | 2.5 |

Table 2. Parameter of productivity and substitution

| |
|---|
| $\gamma=1$; $\mu=0.25$; $\varphi=0.012$; $\phi$[4]$=0.25$ |

Sources: Fougère and Mérette's paper (1999)

Analytical Databank, OECD; Auerbach and Kotlikoff (1987).

4.$\phi$ is the inter-temporal rate of substitution

Table 3. Parameters

| Parameter | | Value |
|---|---|---|
| $\phi$[5] | inter-temporal rate of substitution | 1 |
| | production function parameter | 0.3039 |
| n | population growth rate | 1.13502 |
| te | technique change | 1.12 |
| $\delta$ | physical depreciation rate of capital | 0.1148 |
| b | net government debt | 0.0884 |
| Y | output | 1 |
| K | physical capital | 0.63 |
| N | labor force | 1.5 |
| Ne | initial profile of effective population units | 1 |

5. $\phi$ is the inter-temporal rate of substitution for four years.

Table 4 Factor share in Private production

| Sector | share of capital | share of labor |
|---|---|---|
| 1 | 0.762 | 0.238 |
| 2 | 0.552 | 0.448 |
| 3 | 0.659 | 0.341 |
| 4 | 0.757 | 0.243 |
| 5 | 0.636 | 0.364 |
| 6 | 0.495 | 0.505 |

Source: Andrew Feltenstein , Jiming Ha, Fiscal stabilization (1999)

Original Source:Input-Output Matrix for year 1978 (1986).

Table 5 Factor share in government production

| | Share of capital | share of labor |
|---|---|---|
| 1983 | 0.463 | 0.537 |
| 1984 | 0.461 | 0.539 |
| 1985 | 0.447 | 0.553 |

Source: Andrew Feltenstein , Jiming Ha (1999)

Original Source:Informe Annual 1985 (1980), p.163.

Table 6. Mexico: Macro variables, 1983-1985

| | 1983 | 1984 | 1985 |
|---|---|---|---|
| Public sector revenues[a] | 34.4 | 34.2 | 32.2 |
| Public expenditure[b] | 42.7 | 41.5 | 40.5 |
| Budget balance[c] | -8.3 | -7.3 | -8.3 |
| Interest Rate [d] | 59.2 | 49.5 | 63.4 |

Source: A.Feltenstein and S. Morris, Fiscal stablization ((1990)

Original Source: Source:Indicators Economics

[a] Total revenues as a percent of GDP.

[b]Total expenditure of the public sector as a percent of GDP.

[c]as a percent of GDP.

[d] In percent.

Table 7. Old age dependency ratios in the United States and Mexico:

Population aged 65 and over as a percentage of population aged 15-64

| Country | 1980 | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|---|
| United States | 16.9 | 18.9 | 18.8 | 19.2 | 25.4 | 33.0 | 34.4 | 35.2 |
| Mexico | 7.7 | 7.1 | 7.7 | 9.4 | 12.4 | 17.3 | 25.0 | 31.2 |

Original Source: World Population Prospects (1950-2050) (The 1996 Version)

Data before 1995 are United Nations demographic estimates.

Data after 1995 are United Nations Population division's medium variant population projections.

## Variable definitions

$\varepsilon$ : capital income share (%) production function parameter )

$\gamma$, , : human capital productivity parameter

$1/\theta$ : intertemporal elasticity of substitution

$\tau_k$ : average capital income tax rates

$\tau_w$ : average wage income tax rates

$\tau_c$ : average consumption tax rates

K/Y : capital-output ratio

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