

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

ProQuest Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600

UMI[®]

**ESSAYS ON POPULATION AGING, FISCAL POLICY, AND
INTERNATIONAL TAX EXPORTING**

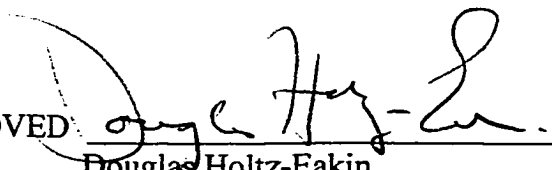
Mehmet Serkan Tosun
B.A., Bogazici University, 1993
M.A., Boston University, 1994

ABSTRACT OF DISSERTATION

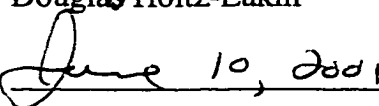
Submitted in partial fulfillment of the requirements for the
degree of Doctor of Philosophy in Economics in
the Graduate School of Syracuse University

June 2001

APPROVED


Douglas Holtz-Eakin

DATE


June 10, 2001

Abstract

This dissertation consists of three essays in public economics. In the first two essays, I examine the relationship between population aging, fiscal policy decisions, and open capital markets. The last essay is a study on international taxation.

In Essay I, I consider projected population aging in both developed and developing countries. This paper explores the roles of both a politically responsive fiscal policy and international capital mobility to explain the effects of worldwide population aging trend on growth and welfare of countries. It also has a scenario analysis for the timing of developing country aging. The results show that the interaction of capital mobility and endogenous fiscal policy may reverse the effects of aging on growth and welfare as predicted by closed economy and exogenous fiscal policy models. Furthermore, countries' reactions differ significantly with the timing of the demographic shocks.

Essay II is coauthored by Douglas J. Holtz-Eakin and Mary E. Lovely. We investigate the effect of a demographic transition on the endogenous determination of public spending for education. A demographic transition alters the identity of the median voter, leading to a preference for less education spending. If the public sector is inefficiently small, demographic transition exacerbates the under-provision of human capital. Alternatively, such a shift may trim an inefficiently large government, reduce tax rates and raise capital per worker enough to *raise* education spending. Thus, there is no automatic link between demographic transition and reduced support for government programs that primarily benefit the young.

The third and the final essay is an empirical study on tax revenue changes and tax exporting incentives. The goal is to provide empirical estimates of the degree to which policymakers take advantage of their ability to substitute exportable domestic taxes for direct taxes on international transactions. I provide evidence that there has been a statistically and economically significant move from international trade taxes to domestic taxes on goods and services in non-OECD countries as a result of significant trade liberalization since mid-1980s. This is particularly important since it may reflect the policymakers' desire to export the taxes on goods and services that cross borders.

**ESSAYS ON POPULATION AGING, FISCAL POLICY, AND
INTERNATIONAL TAX EXPORTING**

Mehmet Serkan Tosun
B.A., Bogazici University, 1993
M.A., Boston University, 1994

DISSERTATION

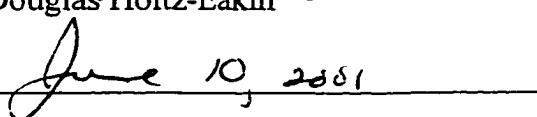
Submitted in partial fulfillment of the requirements for the
degree of Doctor of Philosophy in Economics in
the Graduate School of Syracuse University

June 2001

APPROVED


Douglas Holtz-Eakin

DATE


June 10, 2001

UMI Number: 3019130

Copyright 2001 by
Tosun, Mehmet Serkan

All rights reserved.

UMI[®]

UMI Microform 3019130

Copyright 2001 by Bell & Howell Information and Learning Company.
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

Copyright 2001
Mehmet Serkan Tosun

**The Graduate School
Syracuse University**

We, the members of the Oral Examination Committee,
hereby register our concurrence that

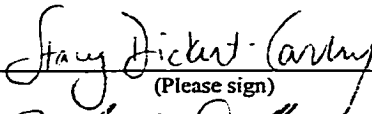
Mehmet S. Tosun

satisfactorily defended his dissertation on

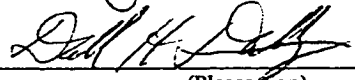
Tuesday, June 05, 2001

Examiners:

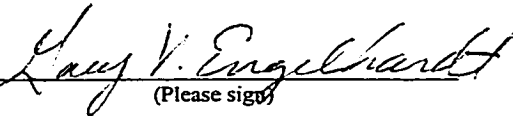
Stacy Dickert-Conlin


(Please sign)

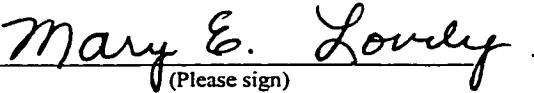
Donald H. Dutkowsky


(Please sign)

Gary V. Engelhardt


(Please sign)

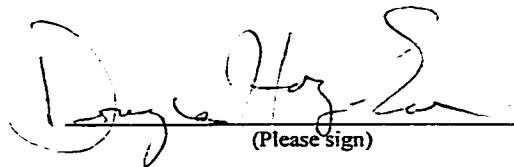
Mary E. Lovely


(Please sign)

(Please sign)

Advisor:

Douglas J. Holtz-Eakin


(Please sign)

Oral Examination Chair:

David C. Popp

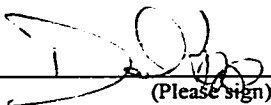

(Please sign)

Table of Contents

	Page No.
Essay I: Endogenous Policy Formation and Capital Market Transmissions in the Presence of Demographic Shocks	1
Introduction	1
Previous Literature	3
The Model	6
Modeling Strategy	6
Household Behavior	9
Political Process.....	11
Producers' Behavior	13
World Equilibrium.....	14
Transition Dynamics in Response to Population Aging.....	17
The Experiment	17
Stability and Capital Stock Transitions	17
The Role of Capital Mobility and Endogenous Fiscal Policy in Capital Stock Transitions	24
Simulation of Transition Effects	25
Simulation Results.....	26
Comparison with Alternative Versions	30
Sensitivity Analysis	32
Alternative Aging Scenarios for Developing Countries	34
Conclusion.....	35
Appendix	37
References	53
 Essay II: Generational Conflict, Fiscal Policy, and Economic Growth	 56
Introduction	56
Modeling Strategy and Policy Preferences	58
The Political Process	64
Production, Equilibrium, and Dynamics	66
Steady State Implications of Demographic Transition	68
Steady-State Comparisons	69
Demographic Transition without Endogenous Politics	71
Demographic Transition with Endogenous Politics	72
Simulation Methods and Steady-State Sensitivities	77
Transition Paths	80
Conclusions	81
Appendix: Stability Analysis.....	83
References	91

Table of Contents (Cont.)

	Page No.
Essay III: Trade Liberalization and Tax Exporting Incentives	94
Introduction	94
Changing Structure of Taxes	97
Theoretical Model.....	100
Empirical Methodology.....	104
Empirical Specification	107
Empirical Results.....	109
Sensitivity Analysis	110
Conclusions	114
References	124

List of Tables and Figures

No.	Title	Page No.
Tables		
I-1	Benchmark Values of the Parameters Used in the Two-Country OLG Model	41
I-2	Comparisons with Alternative Versions	42
I-3	Sensitivity of Simulation Results to Various Values of ψ	44
II-1	Comparative Steady-State Analysis of Effects of Demographic Transitions	87
III-1	Collected Tariff Rates by World Region	116
III-2	Changes in Tax Composition (1980-96) Shares in Total Tax Revenues	117
III-3	Difference-in Differences-in Differences	118
III-4	Descriptive Statistics	119
III-5	Estimation Results	120
III-6	Sensitivity Results	121
Figures		
I-1	Projected Old-Age Dependency Ratios in Developed and Developing Countries	46
I-2	Tax Rate Transitions in Country A and Country B	47
I-3	Human Capital Transitions in Country A and Country B	47
I-4	Capital Stock Transitions in Country A and Country B	48
I-5	World Net Interest Rate Transitions	48

List of Tables and Figures (Cont.)

No.	Title	Page No.
I-6	Balance of Payments Transitions for Country A	49
I-7	Income Transitions in Country A and Country B	49
I-8	Consumption Transitions of Old and Young Generations in Country A and Country B	50
I-9	Welfare Transitions in Country A and Country B	50
I-10	Welfare Transitions for Country A Under Different Aging Scenarios	51
I-11	Welfare Transitions for Country B under Different Aging Scenarios	51
I-12	Capital Stock Transitions for Country A under Different Developing Country Aging Scenarios	52
I-13	Capital Stock Transitions for Country B under Different Developing Country Aging Scenarios	52
II-1	Values of ψ and α Consistent with Higher and Lower Steady-State Income	88
II-2	Government Spending Transitions	89
II-3	Human Capital Transitions	89
II-4	Output Transitions	90
II-5	Capital Stock Transitions	90

Acknowledgments

This dissertation owes a lot to the excellent guidance by my adviser Douglas Holtz-Eakin, and Mary Lovely. I could not have asked for better mentors. I gratefully acknowledge the helpful comments of my other dissertation committee members:

Stacy Dickert-Conlin, Donald Dutkowsky, and Gary Engelhardt.

I benefited from discussions with Muhammed Dalgin, Adam Hill, John Hutton, Jaesang Hwang, Hisahiro Naito, David Richardson, Shalini Sharma, and seminar participants at the Public Policy Institute of California, Syracuse University, West Virginia University, and the University of Genoa, Italy. I thank Esther Gray for her timely help with the formatting of the manuscript, and the faculty and staff at the Department of Economics and the Center for Policy Research for creating such a productive research environment.

I dedicate this dissertation to my family. I would not have been able to bring this work to fruition without the emotional support of a number of people in my life. I owe special thanks to my wife Zeynep, who has constantly provided her loving support and kindness. She has brought perpetual happiness to my life, which has since been the greatest motivating force. My parents, Sermin and Orhan Tosun were always there to help when my confidence faded. I thank them with all my heart. My sister, Oray Posaci, has been a strong force of encouragement throughout my entire graduate school experience. I also thank her for boosting my morale by giving birth to my beautiful niece, Ayda, only few weeks before the completion of my dissertation.

ESSAY I

ENDOGENOUS POLICY FORMATION AND CAPITAL MARKET TRANSMISSIONS IN THE PRESENCE OF DEMOGRAPHIC SHOCKS

1. Introduction

The global economy is experiencing major changes as a consequence of the aging of developed nations' populations. An important and widely ignored characteristic of the recent aging trend is that it influences fiscal policy decision making concurrently with rapid global capital market integration. In a world connected by an international capital market, population aging in one region of the world leads to capital flows by altering saving and consumption behavior and, by extension, changes fiscal policy. An endogenously changing fiscal policy, in turn, affects human capital accumulation by changing government spending for public goods such as education that serve as inputs to human capital. Through these channels, population aging may have unexpected strong growth and welfare implications.

Less well understood is the fact that developing countries are next in this aging trend. Figure I-1 shows the demographic difference between developed and developing countries. Projected changes in old-age dependency ratios¹ between 1990 and 2150 indicate that population aging will occur rapidly in developed countries until 2050. Developing countries are expected to experience equally dramatic population

aging between 2050 and 2150, during which time the dependency ratio levels off in developed countries. Thus, population aging is not confined to developed countries; sooner or later populations of all nations are expected to age.

In this paper, I examine the transition effects of population aging that is occurring in developed countries and that is expected to occur in developing countries in the near future. The paper has two goals. The first goal is to establish the roles of international capital mobility, a politically responsive fiscal policy, and the interaction of the two in explaining the transition effects of population aging. Demographic changes in the developed and developing countries at different periods affect the political process of determining fiscal policies and lead to capital flows by creating interest rate differentials between countries. Thus, I expect to see both domestic and global effects of these demographic changes. The second goal is to compare the effects of different aging scenarios for the developing countries. Because developing country aging is based on population projections, an analysis of the timing of developing country aging will tell us how results might change if actual outcomes differ from projections.

Based on a two-country, two-period overlapping generations model, the results indicate that international capital mobility works like a shock absorber, spreading the effects of aging to both countries. It smoothes consumption and welfare, and brings countries together in their transitions to a new steady state. On the other hand, endogenous fiscal policy has a primary impact on the domestic economy. It drives

¹Old-age dependency ratio is the proportion of population aged 65 and older to population aged 15 to 64.

countries apart in their transitions by creating asymmetries between their fiscal policies. International capital mobility and endogenous fiscal policy together may account for a change in the pattern, beyond a change in the magnitude, of the effects of population aging on economic growth and welfare when compared to closed economy and exogenous fiscal policy models. This contradicts the result by Cutler *et al.* (1990) who suggest that international capital mobility changes the size rather than the pattern of the effects of aging on consumption. The results also show that even when the demographic shocks in developed and developing countries are symmetric in terms of the magnitude, reaction to these shocks depends on their timing. My analysis of the timing of developing country aging indicates that an early population aging scenario is more beneficial for both countries.

The paper is structured as follows. The next section reviews the recent literature on population aging, followed by a description of a two-country, two-period overlapping generations model. The paper then examines dynamic capital stock transitions between pre-aging and post-aging steady states analytically. Transition analysis requires simulation; I then describe the parameters used in the simulation study and present simulation results together with a sensitivity analysis in section 5. The last section presents my concluding remarks.

2. Previous Literature

A number of studies examine macroeconomic effects of population aging. Recent theoretical studies generally lack consideration of effects that emerge from

international capital mobility. However, by allowing for endogenous fiscal policy, some of these studies emphasize the importance of the simultaneity of government policies and the demographic structure of voters. Holtz-Eakin (1993), Meijdam and Verbon (1996), and Holtz-Eakin, Lovely, and Tosun (2000) are closely related to this paper in terms of the fiscal policy aspect of the model structure. Holtz-Eakin (1993), using a modified version of the standard overlapping generations model, allows for endogenous fiscal policy. The author conducts a series of steady state simulations and shows that demographic change has significant impact on the growth of the economy as well as on government expenditure and taxation. Holtz-Eakin, Lovely, and Tosun (2000) use a closed economy setting to address how population aging affects government spending for public education. The study shows that even though demographic shift favors voters with a lower preference for education spending, reduced taxes may raise capital per worker enough to raise education spending. Meijdam and Verbon (1996) use a similar approach to examine, in a closed economy framework, the effect of aging on the economy in general and on the evolution of public pension schemes. However, this study does not model the political process of fiscal policy determination explicitly.

There are also simulation studies with some empirical content. Among these, Auerbach and Kotlikoff (1990) use a 75-period overlapping generations simulation model. They predict that aging decreases United States investment more than it decreases saving, leading to large current account surpluses for the United States between 2000 and 2050. Cutler, Poterba, Sheiner, and Summers (1990), Elmendorf,

and Sheiner (2000) and Börsch-Supan (1996) are recent examples that employ the Cass-Ramsey-Solow growth model. Cutler *et al.*, show for the United States that capital flows change the size rather than the pattern of the effects of aging on consumption. Elmendorf and Sheiner, in a follow-up study to Cutler *et al.*, argue that United States capital could flow to developing countries due to demographic differences over the following decades, causing more saving without a lower rate of return. Börsch-Supan predicts considerable capital flows to slowly aging Southern European Periphery, particularly to Turkey, within the OECD area. Similarly, Kenc, and Sayan (Forthcoming) show in an overlapping generations computable general equilibrium model that population aging in Europe will affect the economy of Turkey substantially in the next several decades through both trade and capital flows. Moreover, Van Groezen, and Leers (2000) analyze international spillovers from population aging in a two-region overlapping generations framework with perfect capital mobility and asymmetric social security arrangements. None of these studies, however, model fiscal policy as endogenously determined through a political process in response to aging.

Another group of studies employs multi-regional dynamic macroeconomic models that build on the consumption model of “perpetual youth” by Blanchard (1985). Of these, Masson and Tryon (1990) is a macroeconometric model that allows for capital flows between industrialized nations. They combine the effect of a higher dependency ratio and higher government expenditures due to aging. Turner, Giorno, De Serres, Vourc’h, and Richardson (1998) employ the OECD “Minilink” model (a

structural dynamic macro model). They allow for capital flows between a group of industrialized countries and the rest of the world, which they divide between “fast-aging” and “slow-aging” countries. They model government behavior by introducing a fiscal reaction function in which the tax rate adjusts gradually to close the gap between current government debt and its exogenous target in the long run. However, in this model public expenditures on education are assumed to change, simply in proportion to the change in population aged less than 15 years old. Although there is a tendency towards allowing for international capital flows, the simulation studies mentioned above either treat fiscal policy as exogenous or they model it in a rather simplified fashion.

While studies mentioned in the beginning of this section highlight the importance of the relationship between population aging and fiscal policy from a political economy perspective, simulation studies above predict substantial capital flows caused by aging. In the light of this review, I intend to analyze the effects of aging by considering capital flows between countries. I will also treat fiscal policy as endogenously determined through a political process that is triggered by the changing demographic structure of voters.

3. The Model

Modeling Strategy

In this section, I describe the three distinct features of my approach. First, this paper employs an extended version of the two-period overlapping generations model

with perfect foresight. By explicitly tracing the life-cycle of savers, overlapping generations models enable a generational or cohort welfare analysis of population aging. This implies that demographic transitions, which take the form of changing relative cohort size, can be important determinants of national saving and the current account.

Secondly, I explicitly model a political process for fiscal policy making. Auerbach and Kotlikoff (1992) assert, “one of the greatest unknowns is how the political process will change as an increasing fraction of the voting population becomes elderly.” Recent discussions of aging have noted the potential generational conflict generated by the need to share society’s resources between non-working elderly and the younger working population. Bös and von Weizsäcker (1989) draw attention to a likely change in the “political framework” by means of population aging. They argue that increasing number of elderly voters may render changes in public expenditure patterns in favor of the elderly. Empirically, Poterba (1997) provides evidence from the United States that older citizens prefer lower levels of public spending for education, an expenditure that primarily benefits the young. A recent study by Harris, Evans, and Schwab (2000) confirms this finding using school-district-level data, however with a smaller estimated impact than Poterba’s estimates. Similarly, Kahn (2000) shows that population demographics are an important determinant of the support for environmental regulation. His results indicate that senior citizens are more likely to find government spending for the environment too high.

While social security payments to old also constitute an important source of conflict between generations, I focus solely on a type of government spending that enhances the productivity of working young. One good example to this is government spending on public education. For simplicity, I will refer to this productivity enhancing public program as “public education.” However, any other government program that is directed towards increasing the labor productivity of young could easily be used. To make the political process of fiscal policy determination rich, interesting, yet tractable, I use a median-voter framework² with voter heterogeneity. I introduce voter heterogeneity by assuming a distribution of genetic ability levels for the working generation. The ability level of the individual will, in turn, determine the value she receives from public education.

Finally, the third aspect of the modeling strategy focuses on transitions between pre-aging and post-aging steady states. I first introduce demographic change in one country (representing developed countries) as an exogenous decrease in their population growth rate. Consistent with the worldwide aging trend in Figure I-1, the population growth rate declines in the other country (representing developing countries) as well after two periods. Population growth rates of the two countries are equal in both the initial and the final steady states.³ Therefore, my analysis focuses on transition between these two steady states.

²The political process can be modeled using a median voter framework because the conditions for the median voter theorem are satisfied. The choice of voters is over a single dimension since the preferred tax rate is the only choice variable, and the voter preferences are single peaked. The property of single-peakedness has been demonstrated to ensure existence of a voting equilibrium (Black 1948).

³In a world with divergent population growth, the region with the higher growth rate continuously gets bigger than the other region. In that case, the post-demographic shock steady state is

The model extends the basic Diamond overlapping generations model⁴ in two ways. First, it is a two-country world economy model similar to Buiter (1981), in which countries are perfectly symmetric in the initial steady state equilibrium. Second, it models political decision making for fiscal policy in order to examine political economy related effects of aging. With an increase in the dependency ratio,⁵ fiscal policy shifts towards the preferences of the older generation. This combines with the effect of international capital mobility when demographic asymmetries (different population growth rates) between countries are present. Internationally mobile capital is the intermediary in spreading the effects of aging globally. For clarity, I first present the model for one country only. Then I describe the two-country world equilibrium. However, this analysis also applies in an asymmetric, two-region model.

Household Behavior

Individuals live for two periods and seek to maximize a lifetime utility function,

$$U = \ln C_{jt} + \left(\frac{1}{1+\delta} \right) \ln C_{jt+1}, \quad (1)$$

not defined. Deardorff (1994) tackles this problem in a modified Solow growth model by including earnings from investment abroad as income of the country.

⁴See Diamond (1965). However, the earliest formalization of an overlapping generations model is due to Allais (1947) and Samuelson (1958).

⁵The dependency ratio is defined as the ratio of elderly to non-elderly persons, (N_{t-1} / N_t) where η_t is the population growth rate. An increase in the dependency ratio is simulated by an exogenous decrease in the population growth rate η_t .

here j indexes individuals, C_{jt} is consumption when young, $C_{j,t+1}$ is consumption when old, and δ is the pure rate of time preference. The period-specific budget constraints in the first and the second periods are:

$$\text{First period: } C_{jt}(a_j) + S_{jt}(a_j) = \theta_t w_t l_t(a_j)$$

$$\text{Second Period: } C_{j,t+1}(a_j) = (1 + \theta_{t+1} r_{t+1}) S_{jt}(a_j), \quad (2)$$

where $\theta_t = (1 - \tau_t)$, $S_{jt}(a_j)$ is first period saving, w_t is the wage rate individual j faces, $l_t(a_j)$ is effective labor,⁶ where a_j is the ability level of individual j , r_{t+1} is the rate of return to capital, and τ_t is the rate of income taxation.

Tax policy is a flat tax on the labor income of the young and the capital income of the old. I also assume there is a continuous distribution of abilities that is replicated in each new generation. The ability level of individual j is indexed by a_j , which ranges from 0 to 1. The density function of abilities is denoted by $f(a)$ where by definition:

$$\int_0^1 f(a) da = 1. \quad (3)$$

Human capital is accumulated from the interaction of ability level (a_j) of the individual and government spending per worker (g_t):

$$l_t(a_j) = \Phi [a_j g_t + 1]^\psi, \quad (4)$$

⁶Here, young supplies one unit of time to the economy. Note that, making the allocation of time between “schooling” and supplying labor endogenous does not change this analysis.

here, Φ denotes an index on human capital efficiency and ψ is a parameter indicating the return to human capital from the inputs (a_j and g_t).⁷ The form of the human capital function is chosen so that even individuals with the lowest ability ($a_j = 0$) will contribute to the economy in terms of human capital (see Holtz-Eakin, Lovely, and Tosun 2000). From the maximization of (1) subject to (2) and (4); we get the familiar first order condition:

$$C_{jt}(a_j) = \frac{1+\delta}{(1+r_{t+1}\theta_{t+1})} C_{j,t+1}(a_j). \quad (5)$$

Using (5) and (2), we derive the optimal saving of an individual j :

$$S_{jt}(a_j) = \frac{1}{2+\delta} \theta_t w_t l_t(a_j). \quad (6)$$

Saving of an individual depends on net labor earnings but it is independent of the interest rate. This is due to the Cobb-Douglas form of the utility function. Given (5) and (6), it is easy to derive consumption functions in each period:

$$\begin{aligned} C_{jt}(a_j) &= \frac{1+\delta}{2+\delta} \theta_t w_t l_t(a_j) \\ C_{j,t+1}(a_j) &= \frac{(1+r_{t+1}\theta_{t+1})(\theta_t w_t l_t(a_j))}{2+\delta}. \end{aligned} \quad (7)$$

Political Process

The consumption and saving decisions, as seen above, depend on human capital, which is in turn determined by government spending (see equation 4). By plugging these into (1), we get the indirect utility function which each voter

⁷ ψ should be less than unity to prevent increasing returns from government spending.

maximizes in determining his or her preferred tax rate, subject to the government budget constraint $(\tau_t y_t = g_t)$.⁸ The preferred tax rate of individual j when young is:

$$\tau_{jt}(a_j) = \frac{a_j \psi y_t - 1}{(1 + \psi) a_j y_t} . \quad (8)$$

Equation (8) is the tax rate each individual prefers based on her ability level. This preferred tax rate is increasing in both ability level a_j and in income per young y_t .

Because the old do not derive any benefit from publicly provided education and there are no bequests in the model, they incur a cost without enjoying any benefits.

Therefore, their preferred tax rate will always be zero, regardless of their ability.

At each period of the model, a cohort of size N_t is born. Then total population in each period is $N_{t-1} + N_t$ where $N_t = (1 + \eta_t) N_{t-1}$ and η_t is the population growth rate at period t . Given this, the median voter is defined by

$$N_{t-1} + N_t \int_0^m f(a) da = \frac{N_{t-1} + N_t}{2} , \quad (9)$$

here m is the ability level of the median voter.

With population aging, the median voter becomes a person with lower ability (see Appendix II) and the preferred tax rate of the median voter is lower. The intuition behind this is as follows: as the population ages (dependency ratio rises), older people will need fewer young voters to form a majority. These young voters are the ones at the lower end of the ability distribution. They prefer lower taxes than higher ability people because their return from public education is lower.

⁸Government uses the entire tax revenue to finance public education for all young equally,

Producers' Behavior

Each country produces a single good using a Cobb-Douglas production technology.

$$Y_t = \Lambda K_t^\alpha H_t^{1-\alpha}, \quad (10)$$

here Λ is the productivity index, K is capital stock and H is aggregate supply of human capital. The aggregate supply of human capital is:

$$H_t = N_t \int_0^1 l(a) f(a) da. \quad (11)$$

Human capital per worker, using (4) and (11), is

$$h_t = \Phi \int_0^1 (ag_t + 1)^\psi f(a) da. \quad (12)$$

Competitive factor markets require that real wage and interest rates are equal to the marginal products of labor and capital respectively. Therefore, factor demand equations are:

$$w_t = (1 - \alpha) \Lambda \left(\frac{k_t}{h_t} \right)^\alpha \quad (13)$$

$$r_t = \alpha \Lambda \left(\frac{k_t}{h_t} \right)^{\alpha-1}. \quad (14)$$

Here, $k_t = K_t / N_t$ and $h_t = H_t / N_t$ are capital stock per worker and human capital per worker, respectively.

regardless of their ability level (Barse, Glomm, and Ravikumar 2000).

Using (6) and (12), saving per worker can be expressed as

$$s_t = \left(\frac{1}{2 + \delta} \right) \theta_t w_t \Phi \int_0^1 (ag_t + 1)^w f(a) da. \quad (15)$$

World Equilibrium

To close the dynamic model, an international goods market condition and an international capital flow constraint must be specified. I assume there is perfect international financial capital mobility.⁹ In each country, claims to domestic and foreign capital are perfect substitutes. International goods market equilibrium requires that world saving is equal to world investment. The domestic capital stock per worker may be higher or lower than the domestic saving per worker, implying international capital flows. Writing this in per worker terms, international goods market equilibrium implies:

$$k_{t+1}^A + \left[\prod_{i=0}^t \frac{(1 + \eta_{i+1}^B)}{(1 + \eta_{i+1}^A)} \right] k_{t+1}^B = \frac{s_t^A}{1 + \eta_{t+1}^A} + \left[\frac{\prod_{i=1}^{t+1} (1 + \eta_i^B)}{\prod_{i=0}^t (1 + \eta_{i+1}^A)} \right] s_t^B, \quad (16)$$

here, superscripts A and B denote countries (or regions). I assume that initial population sizes are the same in both countries (i.e., $N_0^A = N_0^B$).¹⁰ In my model, capital income is taxed where income is earned. Thus, I employ a territorial system of

⁹Feldstein and Horioka (1980) challenge this assumption by providing evidence that net capital flows are actually much smaller. However, Taylor (1996) shows that capital became increasingly mobile since 1980s, thanks to rapid integration of international capital markets. Moreover, in my model one period corresponds to 30 years, which is long enough to consider perfect capital mobility as a viable assumption.

¹⁰When population growth rates of countries are equal in all periods, the expression in (16) is reduced to $k_{t+1}^A + k_{t+1}^B = \frac{s_t^A}{1 + \eta_{t+1}^A} + \frac{s_t^B}{1 + \eta_{t+1}^B}$.

capital income taxation for both countries.¹¹ This implies that net-of-tax interest rates are equalized in equilibrium. Therefore, the international capital flow constraint is:

$$r_{t+1}^A (1 - \tau_{t+1}^A) = r_{t+1}^B (1 - \tau_{t+1}^B) \quad (17)$$

Capital will move between countries until both (16) and (17) hold. I complete my two-country model by introducing balance of payments identities. Balance of payments accounts are especially important in tracing the saving-investment imbalances between countries. Because this is a two-country model, balance of payments of the two countries must sum to zero. Therefore, we have $CA_t^A = -CA_t^B$, $BOT_t^A = -BOT_t^B$, and $FI_t^A = -FI_t^B$; where CA , BOT , and FI stand for current account, balance of trade, and net foreign income, respectively. The current account is the difference between national product and domestic absorption. National product consists of domestic product and net foreign income. Domestic absorption equals the sum of consumption and domestic capital accumulation less taxes. I assume that the consumption good can move costlessly between countries. Given this definition, the current account equation can be written as.¹²

$$CA_t = y_t (1 - \tau_t) + r_t (1 - \tau_t) \left[\frac{s_{t-1}}{1 + \eta_t} - k_t \right] - c_{1t} - \frac{c_{2t}}{1 + \eta_t} - [(1 + \eta_{t+1})k_{t+1} - k_t] \quad (18)$$

¹¹Under a territorial system, capital income is taxed where income is earned. The model tax treaties of the OECD and the United Nations both give source countries the first rights to tax income accrued within their borders. Countries claim this first right of taxation to any investment, domestic or foreign. However, in practice, only few countries have pure territorial taxation (e.g., France, The Netherlands). Other countries such as the United States, England, Canada, and Japan practice a credit imputation system which is a mixed system of territorial and residence taxation. See Gravelle (1994, pp. 229-231) for a detailed comparison of international tax systems. Under a pure residence system, however, the interest rates will be equalized between countries, independent of the tax rates. Therefore, there will not be any direct effect of aging on international capital flows through changing tax rates.

The current account is the sum of balance of trade and net foreign income ($CA_t = BOT_t + FI_t$).¹³ Because this is a one-sector model, “international trade and international lending and borrowing are part and parcel of the same transaction” (Buiter 1981). The only way for a country to consume and invest more than it produces (have a trade deficit) is to hold a net ownership of claims on foreign capital (receive positive net foreign income).

As sketched above, the model incorporates the interaction of household behavior, firm behavior, political process, and international capital flows. Given the aforementioned structure, I expect that the model will behave in the following way. Because the population growth rate changes, the median voter also changes. This leads to a change in government spending for public education, human capital accumulation, capital accumulation, and income per worker. As shown in Appendix II, when the population growth rate falls (increased dependency ratio), the ability level of the “new” median voter will be lower. All else equal, this political transition would reduce provision of the public good. However, if the tax rate decreases, national saving, and thus, physical capital accumulation will be enhanced. This will create a positive effect on income per worker, government spending per

¹²Since the balance of payments accounts are identical in absolute magnitudes, I can take out the country superscripts and present equations for one country.

¹³Balance of trade is the difference between domestic product and domestic absorption and can be written as:

$$BOT_t = y_t(1 - \tau_t) - c_{it} - \frac{c_{2t}}{1 + \eta_t} - [(1 + \eta_{t+1})k_{t+1} - k_t]$$

The net foreign income is earnings from net claims on foreign capital:

$$FI_t = r_t(1 - \tau_t) \left[\frac{s_{t-1}}{1 + \eta_t} - k_t \right]$$

worker and human capital per worker, *ceteris paribus*. When the feedback effect through human capital accumulation dominates the negative effect of a lower preferred tax rate, the demographic shift may induce higher income per worker, higher capital stock per worker, and higher human capital and government spending per worker. However, in an international setting changes in the interest rate in the aging country due to changes in income per worker and capital per worker may lead to capital flows between countries. In the next section, I will examine the transition effects of aging on capital accumulation in both countries. I will also address the issue of stability of the dynamic system.

4. Transition Dynamics in Response to Population Aging

The Experiment

To focus on the role of demographic transition, I assume that the countries are initially identical. As a benchmark, country A is the country that undergoes demographic transition first and it has a lower population growth rate than country B in the first two periods. Country B's population growth rate decreases to country A's growth rate in the third period and the two growth rates are equalized thereafter.

Stability and Capital Stock Transitions

Transitions can be examined by tracing the behavior of the capital stock over time. For this analytical approach, I totally differentiate the equations given by (8), (10), and (12) through (15) for each country, and (16) and (17), which can be reduced to a vector difference equation:

$$F_{t+1} = \Omega F_t + \hat{\Omega} N_t \quad (19)$$

where

$$F_{t+1} = \begin{bmatrix} dk_{t+1}^A \\ dk_{t+1}^B \end{bmatrix},$$

$$F_t = \begin{bmatrix} dk_t^A \\ dk_t^B \end{bmatrix}, N_t = \begin{bmatrix} d\eta_t^A \\ d\eta_t^B \\ d\eta_{t+1}^A \\ d\eta_{t+1}^B \end{bmatrix}$$

and

$$\Omega = \begin{bmatrix} M & M \\ M & M \end{bmatrix}, \quad \hat{\Omega} = \begin{bmatrix} Z_4 & Z_4 & Z_2 - \frac{Z_3}{Z_1} & Z_2 + \frac{Z_3}{Z_1} \\ Z_4 & Z_4 & Z_2 + \frac{Z_3}{Z_1} & Z_2 - \frac{Z_3}{Z_1} \end{bmatrix}$$

The vector difference equation (19) is used for two purposes. First, for a constant population growth across periods, it can be used to examine the stability of the dynamic system. Ω summarizes the relationship between k_t and k_{t+1} . Secondly, for a given capital stock in period t , I examine the effect of a change in the population growth rate on the capital stock in period $t+1$. I will address each of these below.

In order to analyze the stability of the dynamic system, I examine the matrix

$$\Omega \text{ in which } M = \frac{\alpha \left(1 - \frac{\tau^*}{1 - \tau^*} \varepsilon_{\eta} \right)}{2P}, \text{ and } P = 1 - \left[(1 - \alpha) \varepsilon_{hg} (1 + \varepsilon_{\eta}) \right] \text{ within } M.$$

Political equilibrium is locally stable when $P > 0$ and the system is dynamically stable when $2M < 1$ (see the appendix for derivation of the stability conditions).¹⁴ In line

¹⁴Due to Cobb-Douglas, $\varepsilon_{\eta} < \frac{1 - \tau}{\tau}$ which means that $0 < 2M < 1$ (see the appendix for the proof).

with the benchmark experiment described above, we can see how the dynamic system will reach a steady state after a demographic transition.

Expanding (19) for a fixed level of initial capital stock per worker, I can write (19) for $t = 0, 1, 2$ as:

$$\begin{aligned} F_1 &= \Omega F_0 + \hat{\Omega} N_0 \\ F_2 &= \Omega^2 F_0 + \Omega \hat{\Omega} N_0 + \hat{\Omega} N_1 \\ F_3 &= \Omega^3 F_0 + \Omega^2 \hat{\Omega} N_0 + \Omega \hat{\Omega} N_1 + \hat{\Omega} N_2 \end{aligned} \quad (20)$$

Then generalizing this for $t > 2$,

$$F_{t+1} = \Omega^{t+1} F_0 + \Omega^t \hat{\Omega} N_0 + \Omega^{t-1} \hat{\Omega} N_1 + \dots + \Omega \hat{\Omega} N_{t-1} + \hat{\Omega} N_t \quad (21)$$

where $F_0 = \begin{bmatrix} dk_0^A \\ dk_0^B \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

Notice that the coefficients of the terms in (21) resemble a geometric series. In line with my assumptions regarding the demographic transition I can assume that

$N_3 = N_4 = \dots = N_{t-1} = N_t$. Using this, I can write (21) as:

$$\begin{aligned} F_{t+1} &= \Omega^t \hat{\Omega} N_0 + \Omega^{t-1} \hat{\Omega} N_1 \\ &\quad + \Omega^{t-2} \hat{\Omega} N_2 + (\Omega^0 + \Omega^1 + \Omega^2 + \dots + \Omega^{t-3}) \hat{\Omega} N_t \end{aligned} \quad (22)$$

As $t \rightarrow \infty$, the first three terms in the above expression converge to zero and since all the elements of the matrix Ω are less than 1 by dynamic local stability, the geometric series in parentheses converges to $(I - \Omega)^{-1}$. Thus, assuming that

$d\eta_t^A = d\eta_t^B = d\eta$ (identical changes in the steady state population growth rates), as

$t \rightarrow \infty$, (22) can be written as:

$$F_{t+1} = (I - \Omega)^{-1} \hat{\Omega} N \quad (23)$$

By using Ω , and $\hat{\Omega}$, and converting (23) back to the scalar form, we get the change in capital per worker from the initial steady state to the post-demographic transition steady state:¹⁵

$$\frac{dk^A}{d\eta} = \frac{dk^B}{d\eta} = \frac{2(Z_2 + Z_4)}{1 - 2M} \quad (24)$$

where

$$Z_2 = \frac{-k^*}{2(1 + \eta^*)},$$

and

$$Z_4 = \frac{(1 - \alpha)s^* \varepsilon_{hg} \varepsilon_{\alpha} \left(1 - \frac{\varepsilon_{\eta} \tau^*}{1 - \tau^*}\right) - s^* \varepsilon_{\alpha} \frac{\tau^*}{1 - \tau^*} P}{2P\eta^* (1 + \eta^*)^2}$$

Z_2 is negative, while the sign of Z_4 is indeterminate which makes the sign of the derivatives in (24) indeterminate¹⁶. Z_2 is the “direct saving effect”¹⁷ of a change in the population growth rate on capital per worker for a given ability of median voter. Holding the ability of the median voter fixed, a decrease in the population growth rate increases capital per worker by spreading the same saving over fewer workers. Z_4 is the “indirect saving effect”¹⁸ of a change in the ability of median voter on capital per worker. A decrease in the median voter’s ability, triggered by a decrease in the

¹⁵Due to the perfect symmetry of the initial and the final steady states, this open economy steady state formulation is identical to one for a closed economy. See Holtz-Eakin, Lovely and Tosun (2000) for a closed economy analysis.

¹⁶The denominator of (24) is positive since $2M < 1$ by dynamic stability.

¹⁷By “direct” effect, I mean an effect independent of the change in the ability level of the median voter.

¹⁸By “indirect” effect I mean an effect that is driven by a change in median voter’s ability. This effect carries the political economy of population aging.

population growth rate, decreases wage income ($w_t h_t$) while decreasing the tax rate.

Thus, the net effect on net labor income and saving depends on the relative magnitudes of the effects on wage income and the tax rate. The total effect of a decrease in the population growth rate on the steady state capital per worker depends on how the political economy related effect (Z_4) compares to the direct saving effect (Z_2).¹⁹ Notice that Z_4 depends on the elasticity of the preferred tax rate with respect to income per worker ($\epsilon_{\tau y}$), elasticity of the preferred tax rate with respect to median voter's ability ($\epsilon_{\tau a}$), and the elasticity of human capital with respect to government spending per worker (ϵ_{hg}).²⁰ When $\epsilon_{\tau a} = 0$, Z_4 is also equal to zero and steady state capital per worker unambiguously increases with a decrease in η . This is because zero elasticity eliminates completely the feedback effects from an endogenous fiscal policy. Z_4 is increasing in ϵ_{hg} which means that a decrease in government spending decreases human capital per worker more as ϵ_{hg} gets bigger, leading to a greater decrease in labor income, *ceteris paribus*.

Using (19) and (21) for both countries, the dynamic solution of capital per worker caused by a change in the population growth at any period during transition is given by:

¹⁹See Holtz-Eakin, Lovely and Tosun (2000) for a detailed analysis of this comparison.

$$\epsilon_{hg} = \left[\frac{(1+g^*)^\psi (\psi g^* - 1) + 1}{(1+g^*)^{\psi+1} - 1} \right] \text{ and } \epsilon_{\tau y} = \frac{1}{m\psi y - 1}$$

$$\frac{dk_{t+1}^A}{d\eta_{t+1}^A} = \frac{dk_{t+1}^B}{d\eta_{t+1}^B} = \left(Z_2 - \frac{Z_3}{Z_1} \right) \quad \frac{dk_{t+1}^A}{d\eta_{t+1}^B} = \frac{dk_{t+1}^B}{d\eta_{t+1}^A} = \left(Z_2 + \frac{Z_3}{Z_1} \right) \quad (25)$$

$$\frac{dk_{t+1}^A}{d\eta_t^A} = \frac{dk_{t+1}^A}{d\eta_t^B} = \frac{dk_{t+1}^B}{d\eta_t^B} = \frac{dk_{t+1}^B}{d\eta_t^A} = (2MZ_2 + Z_4) \quad (26)$$

where

$$Z_1 = \frac{2[\alpha^2 y'[(1-\tau^*) - \varepsilon_y \tau^*] - P y'(1-\tau^*)]}{k^2 P},$$

$$Z_3 = \frac{(1-P) \alpha y' \varepsilon_w [(1-\tau^*) + \varepsilon_y \tau^*] - \alpha y' \varepsilon_w \tau^* P (1 + \varepsilon_y)}{(1 + \varepsilon_y) k^2 P (1 + \eta^*) \eta^*}$$

In equation (25), Z_1 is the “direct net interest rate effect”²¹ (through capital changes) of a change in the population growth rate in one country and it is negative under the stability conditions.²² For a given ability of the median voter, an increase in capital per worker in one country depresses the net interest rate, which in turn has a negative effect on capital accumulation in that country, *ceteris paribus*.

Z_3 is the “indirect net interest rate effect” through a change in median voter’s ability. The sign of Z_3 is indeterminate which makes the signs of the derivatives in (25) indeterminate as well. For a given level of capital, a decrease in the median

²¹Net Interest rate effects embodied in Z_1 and Z_3 are different from the saving related effects (Z_2 and Z_4) because saving is independent of interest rate due to Cobb-Douglas utility.

²² $Z_1 = \frac{2[\alpha^2 y'[(1-\tau^*) - \varepsilon_y \tau^*] - P y'(1-\tau^*)]}{k^2 P} = \frac{2y'(1-\tau^*) \left[\alpha^2 \left[1 - \frac{\varepsilon_y \tau^*}{(1-\tau^*)} \right] - P \right]}{k^2 P} < 0$ since $\alpha \left[1 - \frac{\varepsilon_y \tau^*}{(1-\tau^*)} \right] < P$ by dynamic stability.

voter's ability decreases the marginal productivity of capital by decreasing income, thus creating a negative effect on the net interest rate. However, it also decreases the tax rate, thus creating a counter effect on the net interest rate. Considering these together, Z_3/Z_1 can be interpreted as the net interest rate effect of a change in median voter's ability on capital per worker after controlling for the effect of capital stock changes on the interest rate (Z_1).

As seen in (25) a change in one country's population growth rate has opposite effects on capital accumulation in two countries. This is due to the change in the net interest rate in one country. The momentary interest rate differential between the two countries will be eliminated by the flow of capital from the country with the lower net interest rate to the one with the higher one. To give an example, holding other effects constant, a decrease in the population growth in only country A at any point in time will decrease the net interest rate in country A as long as the decrease in tax rate is outweighed by the decrease in the interest rate. This, in turn will cause country A capital to flow to country B until the net interest rates are equalized. Notice that when $\epsilon_{\tau a} = 0$, Z_3 is also equal to zero, which drives the net interest rate effect (Z_3/Z_1) to zero. In addition to the interest rate effects mentioned above, capital per worker in period $t+1$ is also affected by saving in period t . Therefore, a change in population growth rate in period t will affect capital per worker in period $t+1$ through a saving effect. This is depicted in (26). The argument is similar to the one for steady state changes. With a decrease in the population growth rate, the direct saving effect controlled for capital growth in period t ($2MZ_2$) increases capital per worker in period

$t+1$ for a given level of median voter's ability. However, a decrease in median voter's ability will also affect saving by decreasing both the labor income and the tax rate, causing the net effect to be ambiguous.

The Role of Capital Mobility and Endogenous Fiscal Policy in Capital Stock Transitions

In order to explore the significance of open economy and endogenous fiscal policy effects, I compare the effects in (25) and (26) with analytic results from two alternative versions of this model. A comparison with a closed economy model shows the influence of capital mobility, while a comparison with an exogenous policy model indicates the importance of endogenous fiscal policy. In the exogenous policy case, I assume that government spending for a productivity-enhancing public good (g) is fixed.²³ Solutions for these models are:

$$\text{Closed economy model: } \frac{dk_{t+1}^A}{d\eta_{t+1}^A} = 2Z_2 \text{ and } \frac{dk_{t+1}^B}{d\eta_t^B} = 2(2MZ_2 + Z_4). \quad (27)$$

$$\text{Exogenous fiscal policy model: } \frac{dk_{t+1}^A}{d\eta_{t+1}^A} = \frac{dk_{t+1}^B}{d\eta_{t+1}^B} = \frac{dk_{t+1}^A}{d\eta_{t+1}^A} = \frac{dk_{t+1}^B}{d\eta_{t+1}^B} = Z_2 \quad (28)$$

$$\frac{dk_{t+1}^A}{d\eta_t^A} = \frac{dk_{t+1}^B}{d\eta_t^B} = \frac{dk_{t+1}^A}{d\eta_t^A} = \frac{dk_{t+1}^B}{d\eta_t^B} = 2M^f Z_2. \quad (29)$$

Comparing (25) and (26) with (27), both the direct saving effect (Z_2), and the indirect saving effect (Z_4) are shared equally between the two countries when these economies are open. The interesting point here is that this result is independent of which country ages. Therefore, I can say that, by spreading the effects of aging

between countries, internationally mobile capital partially offsets the effect of population aging that comes from its effects (direct and indirect) on saving. Comparing (25) and (26) with (27), (28) and (29), it is clear that the net interest rate effect (Z_3/Z_1) is unique to my model, making this a combined effect of capital mobility and endogenous fiscal policy. Since this effect changes capital per worker in A and B in opposite directions, it is a major factor in creating an asymmetry between the two countries throughout the demographic transition. Through this effect, the pattern as well as the magnitude of the effect of aging may change. Next, in a simulation exercise, I examine the direction and magnitude of the effects mentioned above and how sensitive they are to model parameters.

5. Simulation of Transition Effects

The simulation study consists of transition analysis of population aging in both countries at different time periods. I assume that both countries are at an identical steady state in period 0. Population aging is simulated by a decrease in the population growth rate (or an increase in the dependency ratio) from an annual 2 percent rate to an annual 1 percent rate. In the benchmark simulation, country A ages starting at period 1 while country B retains its demographic structure until period 3. The population growth rates between the two countries are equalized in period 3 and thereafter. The parameter values used in the numerical simulation are shown in Table I-1. The elasticity of output with respect to capital input is set equal to one-third

²³Government spending, rather than the tax rate, is fixed because this enables me to do a comparison in the presence of inefficiencies stemming from choosing a suboptimal value of g . Fixing

($\alpha = 0.33$).²⁴ The annual rate of time preference is chosen to be 4 percent.²⁵ Notice that two parameters, the rate of time preference in the utility specification and the population growth rate, are adjusted to the length of the model period (30 years). The values for the scale parameters in the production function (Λ) and in the human capital supply function (Φ) are chosen arbitrarily and not shown in Table I-1. These parameters determine only the units of measurement and they are not crucial for the simulations. In these simulations, I assume that the ability level, a , is distributed uniformly on the interval $[0,1]$. These parameter values and the timing of population aging mentioned above describe the benchmark simulation. A series of sensible values for the efficiency of public education in raising human capital (ψ) are chosen to conduct a sensitivity analysis as explained in a later section.

Simulation Results

As expositied above, with an increase in the dependency ratio older people will form a majority with fewer young people at the lower end of the ability distribution. Therefore, the ability of the median voter is lower than in country A, but unchanged in country B until period 3, after which it is the same in both countries. Figure I-2 shows the implications of this on the preferred tax rate. In both countries, the tax rate decreases in the first period of their respective demographic shocks. Then the tax rate

the tax rate, however, allows for changes in government spending with changes in the tax base.

²⁴This elasticity estimate is consistent with the data from the United States. See Laitner (2000) for an argument.

²⁵Caldwell, Favreault, Gantman, Gokhale, Johnson, and Kotlikoff (1999) argue that a premium of riskiness should be added to the widely used 2 percent rate. They use 3.5 percent as the discount rate which is the real safe return on indexed Treasury bonds. See Coronado, Fullerton and Glass (2000) for a recent argument on the variety of discount rates used in studies of social security. They assert that the selection of discount rates ranges between 2 to 5 percent.

increases in both countries following this first period shock. This is due to income growth (see below) in both countries, and the fact that the preferred tax rate exhibits positive income elasticity. In my model, the lower tax rate in the aging country, *ceteris paribus*, causes lower government spending and this causes deterioration in human capital accumulation. In Figure I-3, human capital per worker decreases in country A in period 1 and in country B in period 3. However, again due to income growth, human capital increases in both countries following their first period of aging, and both countries end up with a higher steady state human capital per worker.

Above, I have shown that the effect of a decrease in population growth rate on capital per worker is indeterminate due to the political economy of a changing median voter. Figure I-4 shows that with the parameter values chosen for simulation, the capital stock per worker increases (capital deepening) in both countries throughout the entire transition. After the first demographic shock in country A, the abundance of capital per worker compared to a decreasing human capital per worker depresses the domestic interest rate in country A. At a lower interest rate, demand for capital increases in country B, causing capital to flow to country B. Capital per worker is higher in country B than in country A during the first two periods because the decrease in the ability of median voter in A depresses the net interest rate (Figure I-5) in A even further causing more capital to flow to country B. The second demographic shock, which takes place in country B in period 3, boosts capital accumulation in both countries. The increase in capital per worker in the second shock is larger because both economies are growing prior to the second shock.

For a better understanding of the capital movements between countries, I examine the changes in the balance of payments. I graph only the balance of payments of country A, as the balance of payments accounts in country B are just the opposite of country A. Due to perfect foresight assumption, the decrease in country A's population growth rate in period 1 leads to a drop in period 0 domestic investment. In Figure I-6, starting at a zero net foreign income, this generates a current account surplus for country A in periods 0 and 1. Thus, capital moves from country A to country B from period 0 to period 2. This explains the increase in the capital stock per worker in country B in the first two periods as seen in Figure I-4. This also leads to positive net foreign income for country A in periods 1 and 2. With the arrival of the second demographic shock, however, country A incurs a large trade and current account deficit in period 2. This means that capital flows from country B back to country A from period 2 to period 3, leading to greater increase in capital stock per worker in country A in period 3. Also, in period 3, country A has negative net foreign income and a trade surplus. Because trade surplus outweighs negative net foreign income, country A has a current account surplus and capital flows from country A to country B again. However, since economic variables converge rapidly to their new steady state values after period 4, current accounts and trade accounts of both countries are balanced thereafter.

These results for capital per worker and human capital per worker tell us how income responds to the demographic transition. For the first demographic shock, due to the capital inflow to country B until period 2, both capital and human capital per

worker increase in country B leading to an increase in income per worker in the first two periods. On the other hand, even though the capital per worker increases in A, human capital per worker decreases in period 1. The income transitions in Figure I-7 show that the decrease in human capital dominates, leading to a decrease in the income per worker in country A in the first period. In the second period however, due to both capital and human per worker increases, income per worker increases in country A. When the second demographic shock hits country B, unlike the first shock, there is income growth in both countries. Thus, country B does not experience the same income deterioration as country A did in the first shock even though the shock itself is identical in both cases. This interesting result, which is a clear indication of asymmetric economic transitions of countries aging at different times, can be explained by the observation that economies are growing prior to the second demographic shock.²⁶ Therefore, this “growth effect” partially offsets the adverse effects of population aging for country B.

Welfare effects of aging can be examined by defining welfare in period t as the lifetime welfare of a person of generation t .²⁷ Welfare of this person is composed of her consumption when young (in period t) and consumption when old (in period $t + 1$). In order to examine welfare effects, I derive an indirect utility function by substituting consumption solutions in (7) into (1), and I integrate this over the ability distribution. To understand welfare changes, I will first examine consumption transitions. In Figure I-8, consumption of old persons of generations 0 and 2

²⁶In contrast, I assume that both economies are at a steady state prior to the first demographic



decreases in both countries immediately after the two shocks. On the other hand, consumption of young persons of all generations increases in both countries throughout the entire demographic transition. The decrease in the consumption of old has to do with the perfect foresight assumption in my overlapping generations model. In periods 0 and 2, consumers internalize the steep decrease in the net of tax interest rate (see Figure I-5) in periods 1 and 3. Thus, young persons who save in periods 0 and 2 will consume less from a given level of savings in their old age in periods 1 and 3. This result explains welfare changes in periods 0 and 2.

Figure I-9 shows that welfare levels of generations 0 and 2 drop in both countries. However, notice that the decrease in welfare in period 2 is less pronounced than the decrease in period 0. The answer to this puzzle lies at the increase in consumption of young in period 2, which is again the consequence of an already growing economy prior to the second shock. As hinted by the simulation results in this section, international capital mobility and the political economy of a changing median voter are the key factors in understanding the effects of population aging on the economic transitions of countries. In the following section, I compare the results presented above with the results from alternative versions of my model.

Comparison with Alternative Versions

I begin, in Table I-2, by comparing the effects of demographic transitions in an open world economy to those in a world without capital mobility. The open economy results in columns (3), (4), and (5) are considerably different from the closed economy

shock.

²⁷Generation t refers to persons who are young in period t and old in period $t + 1$.

results in columns (1) and (2). The open economy results with exogenous fiscal policy in column 3 are identical for both countries. As mentioned in the analytical section, by affecting capital accumulation in both countries in opposite directions, a politically determined fiscal policy single-handedly creates asymmetric results for countries. On the other hand, comparing the closed economy results with the open economy results, capital mobility acts as a shock absorber, spreading the effects of aging to both economies. While capital flows smooth consumption and welfare in country A for the first demographic shock, they smooth consumption and welfare in country B for the second shock. These results suggest that the interaction of open economy and endogenous fiscal policy changes the magnitude of the effects of aging in a considerable way.

An even more striking result is that it is possible to change the pattern as well as the magnitude of these effects. Aging increases country A's income per worker in the closed economy version, but it decreases first period income per worker in country A in the open economy model with endogenous fiscal policy. The explanation lies in the relatively smaller increase in the first period capital stock and greater decrease in first period human capital and government spending per worker in country A. Another change is seen in welfare transitions. Unlike the closed economy results, the open economy results in columns (3) and (4) show that the welfare of generation 0 in country B and welfare of generation 2 in country A both decrease because of the decreases in old age consumption.

Finally, results in columns (3)-(5) show that there are transition asymmetries between the first and the second demographic shocks. In terms of welfare, both countries are better off in the second shock compared to the first one. This can be explained by the economic growth that is taking place prior to the second demographic shock. Therefore, even though the demographic shocks are symmetric (a decrease in population growth from 2 percent to 1 percent), the economic transitions are not.

Sensitivity Analysis

The simulations, described in the previous sections, are based on the parameter values presented in Table I-1. Among those, the parameter of the human capital function (ψ), which can be interpreted as the return, in terms of human capital, from government spending, is an important aspect of the model and the welfare results. Accordingly, in Table I-3 I present the results of a sensitivity analysis for ψ . Higher values of ψ are associated with higher values of the elasticity of human capital with respect to government spending per worker (ϵ_{hg}) and lower values of the elasticity of the preferred tax rate with respect to median voter's ability ($\epsilon_{\tau a}$). Thus, for a high value of ψ , there will be a relatively smaller decline in the tax rate and government spending from a decrease in median voter's ability, while there will be a relatively greater human capital feedback from government spending for a given ability level. For $\psi = 0.7$ in columns (5) and (6), countries overall have more favorable transitions, indicated by capital, income and welfare growth throughout the transition periods. However, for $\psi = 0.35$, the decrease in government spending and human capital due

to a decrease in median voter's ability is so large that there is even a decrease in capital per worker in period 2 in both countries. This leads to substantial welfare deterioration in periods 1 and 2 for country A and in period 2 for country B.

The sensitivity analysis shows that while the open economy is more likely to change the pattern of the closed economy results for lower values of ψ , consumption and welfare smoothing effect of capital mobility is more apparent for higher values of ψ . In terms of the welfare reactions, both countries are better off in the second demographic shock compared to the first one conditioned on previous capital growth. Finally, the qualitative results are overall robust to an alternative utility function. Simulations for a Constant Relative Risk Aversion (CRRA) utility function²⁸ give similar results to the ones presented in Table I-3. For $\psi = 0.5$, and $\psi = 0.7$ the results are mainly the same except for the magnitude. For lower values of ψ , capital growth is lower than the logarithmic utility case, which stems from saving response to interest rate decreases.²⁹

²⁸Unlike Cobb-Douglas, saving in the CRRA utility case is a function of the interest rate:

$$S_t(a_t) = \frac{\theta_t w_t h_t(a_t)}{1 + (1 + \delta) \frac{1}{\gamma} (1 + r_{t+1} \theta_{t+1})^{\frac{\gamma-1}{\gamma}}},$$

where γ is the coefficient of relative risk aversion. However, since there is no uncertainty in the model, γ here indicates the willingness by households to shift consumption between periods. The smaller is γ , the more slowly the marginal utility of consumption decreases as consumption increases. Hence, intertemporal elasticity of substitution for consumption is $\frac{1}{\gamma}$. γ is set equal to 0.5 in my simulations.

Simulation results for the CRRA case are available from the author upon request.

²⁹For $0 < \gamma < 1$, the substitution effect of a change in the interest rate dominates the income effect, and hence $S_r > 0$.

Alternative Aging Scenarios for Developing Countries

The old-age dependency ratios in Figure I-1 are based on population projections for developed and developing countries in the next 150 years. What happens if developing countries age sooner or later than embodied in these projections? Is the timing of developing country aging really important? This section addresses the implications of the timing of demographic shocks. I consider two alternative scenarios. In the first scenario, country B ages a period sooner, so the second demographic shock is introduced in period 2 rather than in period 3. In the second scenario, country B ages a period later, so the shock is introduced in period 4. Figures I-10 and I-11 show the welfare transitions for country A and country B under these alternative aging scenarios.

The pattern of the affects changes significantly with the timing of aging. In the early aging scenario, both countries enjoy higher welfare after period 1 compared to other scenarios, whereas in the late aging scenario, there is considerable welfare reduction for both countries in period 3. This scenario produces the lowest welfare transition in both countries after period 2 compared to other scenarios. This unattractive implication can be understood by examining the capital stock transitions in Figures I-12 and I-13. After an initial boost from the first demographic shock, capital per worker actually decreases in both countries in period 3 in the late aging scenario. The main reason for this is that the effect of an initial increase in savings that drives capital accumulation (direct saving effect) dissipates and diminishes over time unless there is another similar shock. The decrease in capital per worker occurs

one period before the second demographic shock. Also, capital per worker increases again in both countries in period 4. These findings suggest that the timing of developing country aging has strong welfare implications for both countries in their transitions to a new steady state. An early aging scenario seems to provide favorable welfare transitions for both countries.

6. Conclusion

In this paper, I examined the transition effects of population aging in developed countries followed by aging of developing countries. By changing the political balance in favor of the preferences of older generations, population aging has a direct impact on government spending policy. This triggers changes in the economy of both the aging country and other countries through the medium of internationally mobile capital. The analytical and numerical simulation exercises show that capital mobility and an endogenous fiscal policy together may reverse the effects of population aging on economic growth and welfare as predicted by closed economy and exogenous fiscal policy models. While capital mobility has consumption and welfare smoothing effects, endogenous fiscal policy is the key factor in creating asymmetries between countries. The results also show that even when the demographic shocks in developed and developing countries are symmetric in terms of the magnitude, reaction to these shocks depends on their timing. Finally, in an attempt to examine the implications of the timing of developing country aging, I considered an

early aging and a late aging scenario. These simulations indicate that an early aging scenario is more beneficial, in terms of long-term welfare, for both countries.

Appendix

I. Stability

Stability of the Political Equilibrium

The political equilibrium is locally stable if starting from a given level of government spending (g), the economy moves automatically to an equilibrium (Holtz-Eakin, Lovely, and Tosun 2000). For an analysis of stability, I assume a Marshallian-type adjustment rule:

$$\frac{dg}{dt} = c \left[\frac{\tau_p}{\tau} - 1 \right] = \varphi(g) \quad (\text{A.1})$$

In this expression c is a positive constant. The variable τ is the actual tax rate, which is a function of government spending per worker and income per worker. The variable τ_p is median voter's preferred tax rate for a given level of government spending and income. Equation (A.1) states that if median voter's preferred tax rate exceeds actual tax rate, government spending will rise. For a political equilibrium, $\varphi(\hat{g}) = 0$ and $\hat{g}$ is locally stable if and only if $\varphi'(\hat{g}) < 0$ (where $\hat{g}$ is the equilibrium level of government spending). Differentiating (8), (10) and (14) in the text, we get:

$$d\tau_p = \frac{1}{y^*} (1 - \alpha) \varepsilon_{hg} \varepsilon_{gy} dg, \quad (\text{A.2})$$

Differentiating the government budget constraint $(\tau, y_t = g_t)$ and using the differentiated form of (10), we get:

$$d\tau_t = \frac{[1 - (1 - \alpha)\varepsilon_{hg}]}{y^*} dg_t \quad (\text{A.3})$$

Finally, differentiating (A.1) and using (A.2) and (A.3), I get the stability condition for political equilibrium:

$$1 - [(1 - \alpha)\varepsilon_{hg}(1 + \varepsilon_{\tau_y})] > 0 \quad (\text{A.4})$$

This makes P in the text positive.

Stability of the Intertemporal Equilibrium

B.1 Intertemporal stability requires that the eigen value of the matrix $\Omega_{2 \times 2}$ in (19) is less than 1 in absolute value. Eigen value is found by solving $|\Omega - \lambda I| = 0$, where λ is the eigen value and $I_{2 \times 2}$ is the identity matrix. The two possible values of λ are:

$$\lambda = 0 \text{ or } \lambda = 2M = \frac{\alpha \left(1 - \frac{\tau^*}{1 - \tau^*} \varepsilon_{\tau_y} \right)}{P} \quad (\text{A.5})$$

Using the nonzero root, intertemporal stability requires:

$$|\lambda| < 1 \text{ or } |2M| = \left| \frac{\alpha \left(1 - \frac{\tau^*}{1 - \tau^*} \varepsilon_{\tau_y} \right)}{P} \right| < 1$$

However, since $\varepsilon_{\tau_y} < \frac{1 - \tau}{\tau}$ (as shown in the proof below) and $P > 0$ by political

stability, $2M$ is positive and the intertemporal stability condition can be written as:

$$\alpha \left(1 - \frac{\tau^*}{1 - \tau^*} \varepsilon_{\tau_y} \right) < P \quad (\text{A.6})$$

B.2 $2M > 0$

Proof by contradiction: Let $\varepsilon_y \geq \frac{1-\tau}{\tau}$,

Since $\varepsilon_y = \frac{1}{m\psi y - 1}$

and $\frac{1}{m\psi y - 1} \geq \frac{1}{\tau} - 1$,

then $\frac{m\psi y}{m\psi y - 1} \geq \frac{(1+\psi)my}{m\psi y - 1}$

which cannot be true since $m\psi y - 1 > 0$ and $\psi > 0$, $m > 0$, $y > 0$. Then $\varepsilon_y < \frac{1-\tau}{\tau}$,

and under political stability ($P > 0$) this implies $2M > 0$.

II. The Effect of Increasing Dependency Ratio on the Ability Level of the Median Voter

Recall that median voter is defined by $N_{t-1} + N_t \int_0^m f(a) da = \frac{N_{t-1} + N_t}{2}$.

Rewriting this: $N_{t-1} + N_t F(m) - N_t F(0) = \frac{N_{t-1} + N_t}{2}$, dividing both sides by N_{t-1} :

$1 + (1 + \eta_t) \{F(m) - F(0)\} = \frac{2 + \eta_t}{2}$ can be rearranged as $F(m) - F(0) = \frac{\eta_t}{2(1 + \eta_t)}$..

Differentiating both sides we get, $F'(m) dm = \frac{2(1 + \eta_t) d\eta_t - 2\eta_t d\eta_t}{4(1 + \eta_t)^2}$. Finally this can

be rearranged as $\frac{dm}{d\eta_t} = \frac{2}{F'_{(+)}(m) 4(1 + \eta_t)^2}$ which is positive. Therefore, with a

decrease in the population growth rate the ability level of the median voter will be lower.

Table I-1. Benchmark Values of the Parameters Used in the Two-Country OLG Model

	Rates Translated into One-Period (30 Years)	Annual Rate
Rate of time preference (δ)	2.24	0.04
Population growth rate (η)	0.81	0.02
Elasticity of human capital w.r.t. inputs of ability and government spending (ψ)	0.50	
Elasticity of output w.r.t. capital (α)	0.33	

Source: Computed by author.

Table I-2. Comparisons with Alternative Versions*

	Time Periods	Closed Economy		Open Economy		
		Country A	Country B	Exogenous Policy		Endogenous Policy
				Country A and B	Country A	Country B
		(1)	(2)	(3)	(4)	(5)
Capital stock per worker	1	34.39	0.00	14.67	13.26	15.72
	2	13.59	0.00	4.10	3.68	3.59
	3	6.25	34.39	21.87	23.55	21.02
	4	2.93	13.59	9.05	9.13	9.13
	steady state	71.42	71.42	69.39	71.42	71.42
Human capital per worker	1	-3.09	0.00	0.00	-8.42	3.87
	2	4.19	0.00	0.00	1.22	0.92
	3	1.94	-3.09	0.00	7.17	-5.23
	4	0.91	4.19	0.00	2.82	2.82
	steady state	4.73	4.73	0.00	4.73	4.73
Income per worker	1	7.95	0.00	4.62	-1.77	7.64
	2	7.20	0.00	1.33	2.03	1.79
	3	3.35	7.95	6.74	12.32	2.74
	4	1.57	7.20	2.90	4.86	4.86
	steady state	23.22	23.22	19.00	23.22	23.22
Government spending per worker	1	-7.25	0.00	0.00	-19.22	9.41
	2	10.33	0.00	0.00	3.03	2.17
	3	4.66	-7.25	0.00	18.27	-11.94
	4	2.17	10.33	0.00	6.85	6.85
	steady state	11.56	11.56	0.00	11.56	11.56

Table I-2. Continued

	Time Periods	Closed Economy		Open Economy		
		Country A	Country B	Exogenous Policy		Endogenous Policy
				Country A and B	Country A	Country B
		(1)	(2)	(3)	(4)	(5)
Consumption of young	1	13.59	0.00	6.34	4.71	6.98
	2	6.26	0.00	1.80	1.74	1.65
	3	2.93	13.59	9.06	10.59	8.33
	4	1.39	6.26	3.81	4.25	4.25
	steady state	27.55	27.55	26.05	27.55	27.55
Consumption of old	1	-12.24	0.00	-5.75	-5.97	-5.97
	2	8.00	0.00	4.51	3.18	5.42
	3	3.76	-12.24	-6.49	-6.52	-6.61
	4	1.78	8.00	5.10	6.86	4.68
	Steady state	1.73	1.73	0.53	1.73	1.73
Welfare	0	-3.93	0.00	-1.80	-1.90	-1.90
	1	16.25	0.00	7.79	5.60	8.81
	2	7.54	-3.93	-0.29	-0.36	-0.46
	3	3.52	16.25	10.76	13.03	9.81
	4	1.66	7.54	4.49	5.10	5.10
	steady state	28.31	28.31	26.25	28.31	28.31

*All numbers are percentage changes from the previous period. Numbers for steady state indicate percentage change between the initial and the final steady state.
Source: Computed by author.

Table I-3. Sensitivity of Simulation Results to Various Values of ψ *

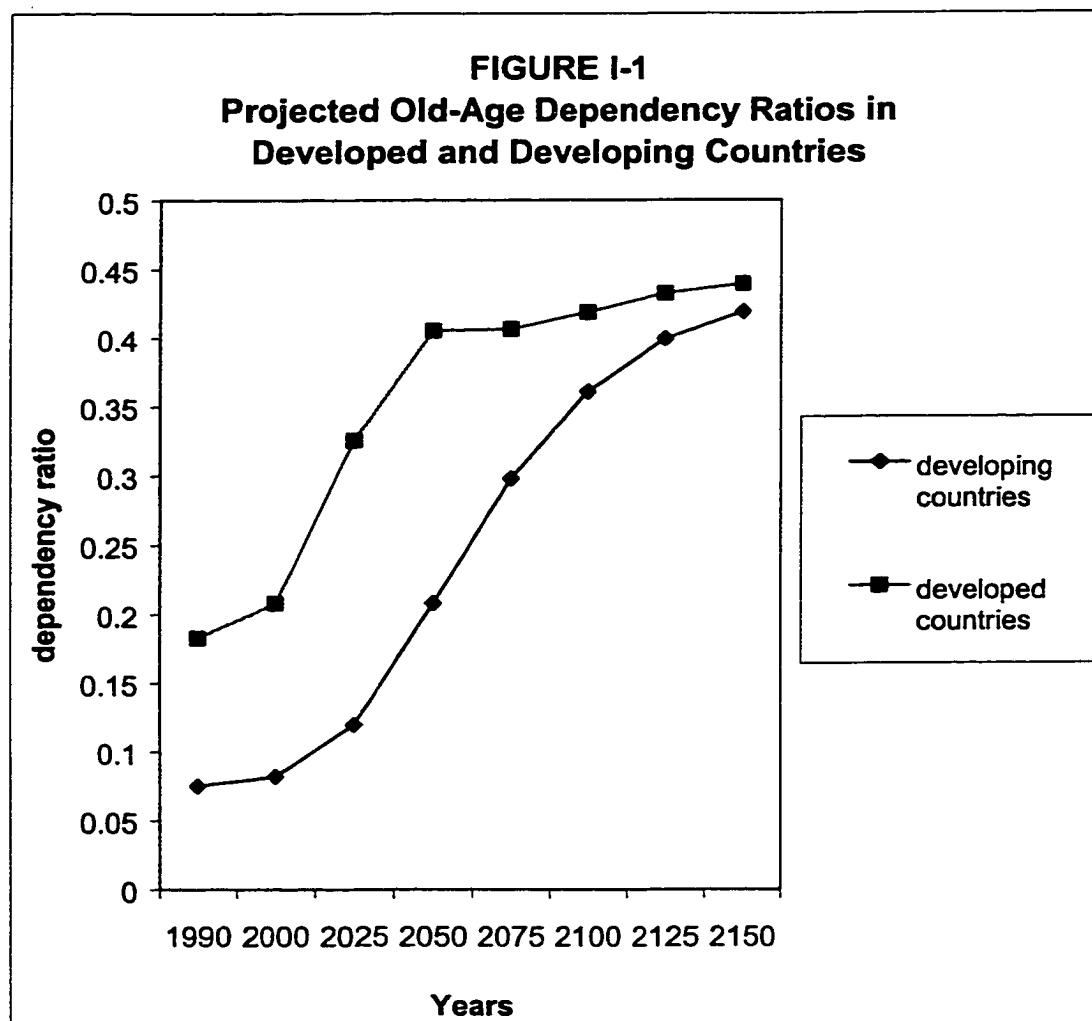
ψ		0.35		0.5		0.7	
Time	Country A	Country B	Country A	Country B	Country A	Country B	
Periods	(1)	(2)	(3)	(4)	(5)	(6)	
Capital stock per worker	1	6.70	20.61	13.26	15.72	14.07	15.12
	2	-0.95	-0.60	3.68	3.59	6.24	6.20
	3	30.72	15.23	23.55	21.02	25.02	23.92
	4	5.98	5.98	9.13	9.13	14.08	14.08
	steady state	53.99	53.99	71.42	71.42	113.56	113.56
Human capital per worker	1	-26.91	3.39	-8.42	3.87	3.37	6.35
	2	-0.69	-0.11	1.22	0.92	2.78	2.66
	3	15.31	-18.96	7.17	-5.23	10.59	7.61
	4	2.34	2.34	2.82	2.82	6.09	6.09
	steady state	-12.70	-12.70	4.73	4.73	37.03	37.03
Income per worker	1	-17.19	8.78	-1.77	7.64	6.79	9.17
	2	-0.78	-0.27	2.03	1.79	3.91	3.82
	3	20.19	-8.98	12.32	2.74	15.16	12.74
	4	3.53	3.53	4.86	4.86	8.66	8.66
	steady state	5.28	5.28	23.22	23.22	58.64	58.64
Government spending per worker	1	-91.63	15.98	-19.22	9.41	4.97	9.42
	2	-14.02	-0.46	3.03	2.17	4.08	3.91
	3	419.65	-67.62	18.27	-11.94	15.81	11.29
	4	16.96	16.96	6.85	6.85	8.99	8.99
	steady state	-50.73	-50.72	11.56	11.56	58.24	58.24

Table I-3. Continued

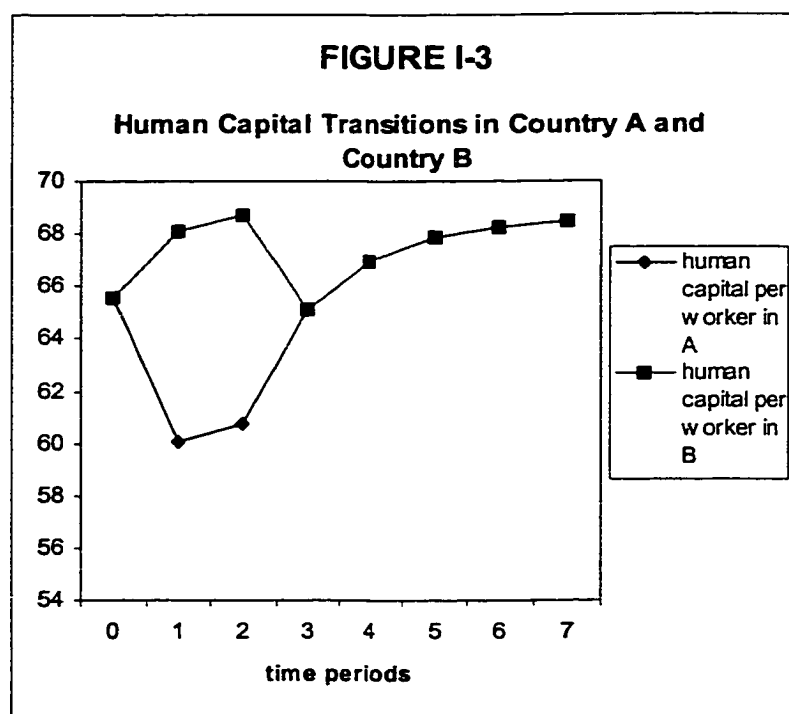
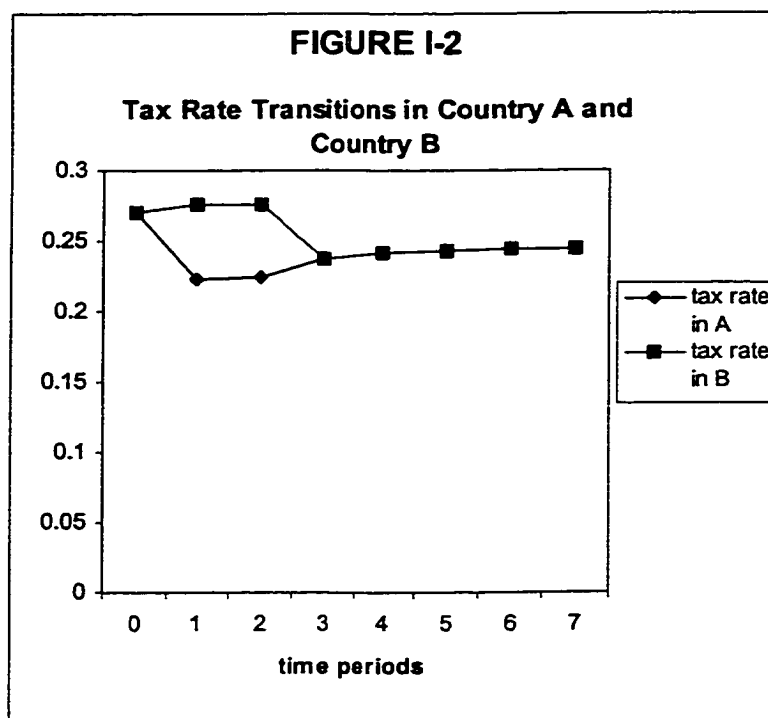
ψ		0.35		0.5		0.7	
Time	Periods	Country A	Country B	Country A	Country B	Country A	Country B
		(1)	(2)	(3)	(4)	(5)	(6)
Consumption of young	1	-4.83	7.58	4.71	6.98	8.00	9.00
	2	-0.58	-0.23	1.74	1.65	3.79	3.76
	3	15.14	1.50	10.59	8.33	14.73	13.72
	4	2.76	2.76	4.25	4.25	8.45	8.45
	steady state	14.58	14.59	27.55	27.55	58.91	58.91
Consumption of old	1	-8.54	-8.54	-5.97	-5.97	-4.21	-4.21
	2	-4.56	7.89	3.18	5.42	6.05	7.04
	3	-9.73	-9.42	-6.52	-6.61	-2.85	-2.89
	4	12.53	-0.81	6.86	4.68	10.42	9.44
	steady state	-8.61	-8.61	1.73	1.73	26.75	26.75
Welfare	0	-2.74	-2.74	-1.90	-1.90	-1.32	-1.32
	1	-6.54	10.22	5.60	8.81	9.99	11.34
	2	-3.72	-3.25	-0.36	-0.46	2.88	2.83
	3	19.59	0.91	13.03	9.81	18.33	16.95
	4	3.32	3.32	5.10	5.10	10.42	10.42
	steady state	11.21	11.21	28.31	28.31	71.12	71.12

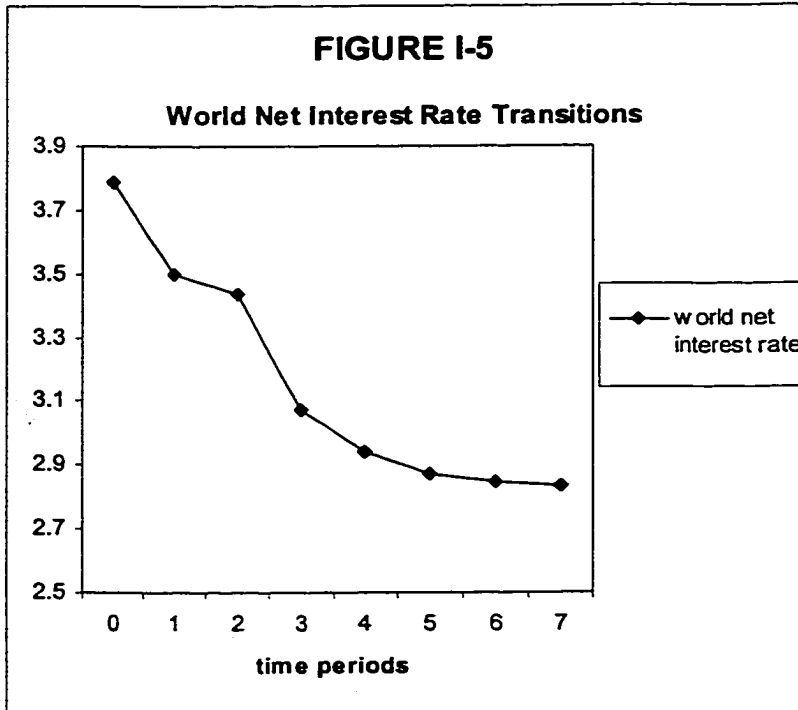
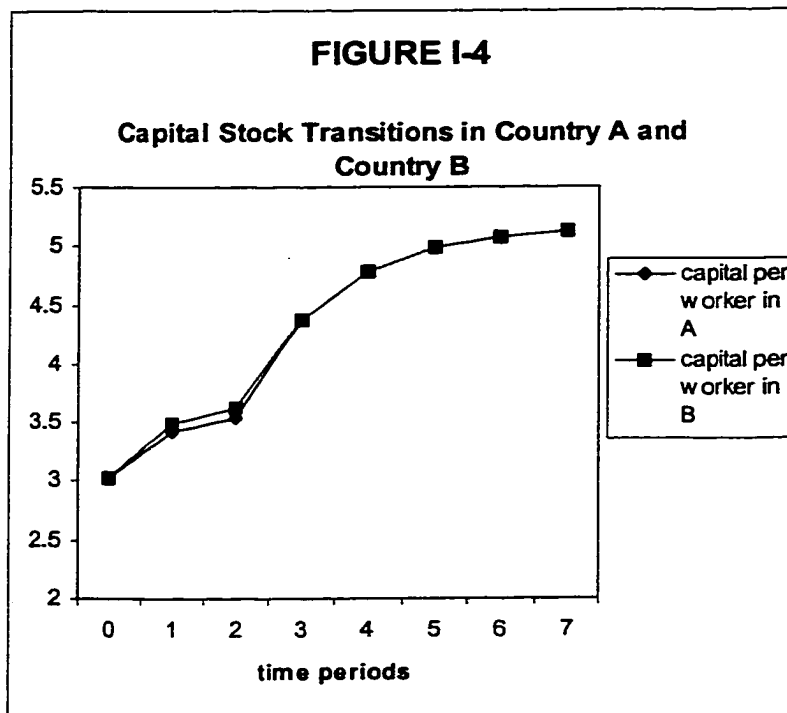
*All numbers are percentage changes from the previous period. Numbers for steady state indicate percentage change between the initial and the final steady state.

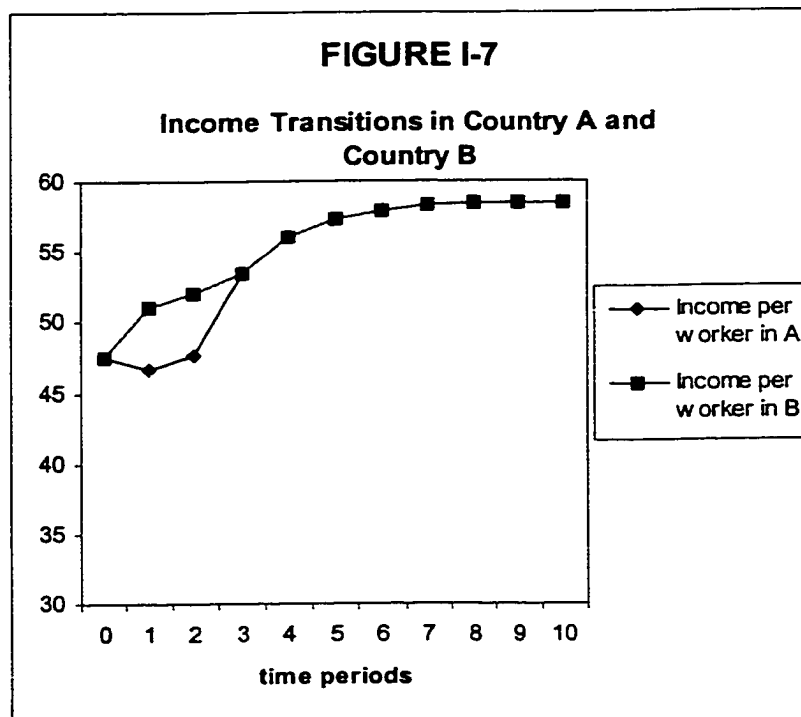
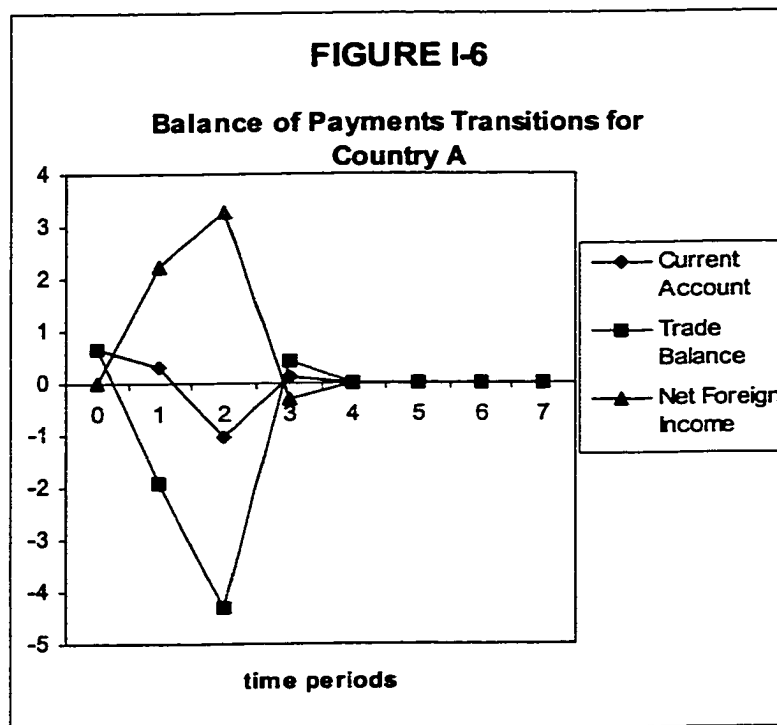
Source: computed by author.

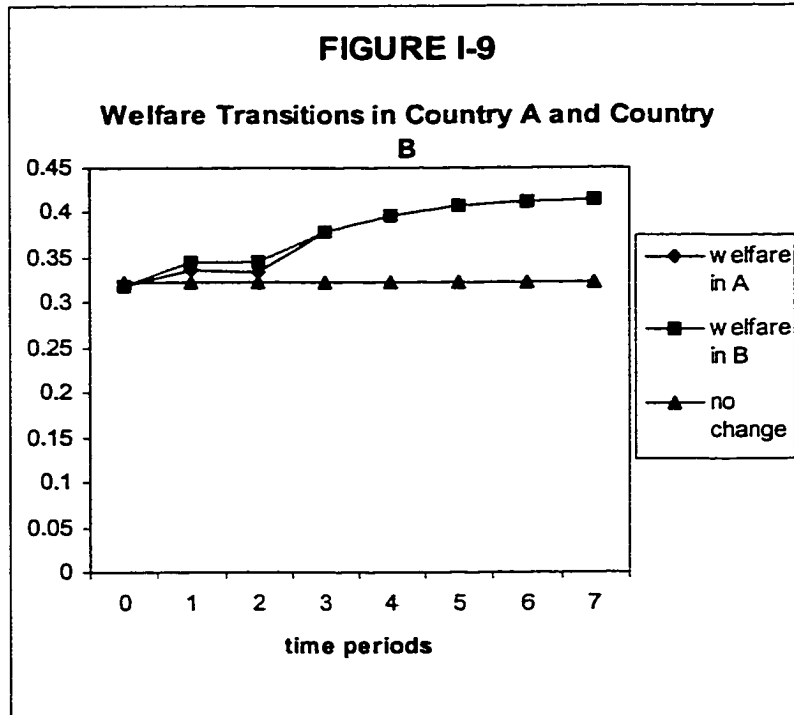
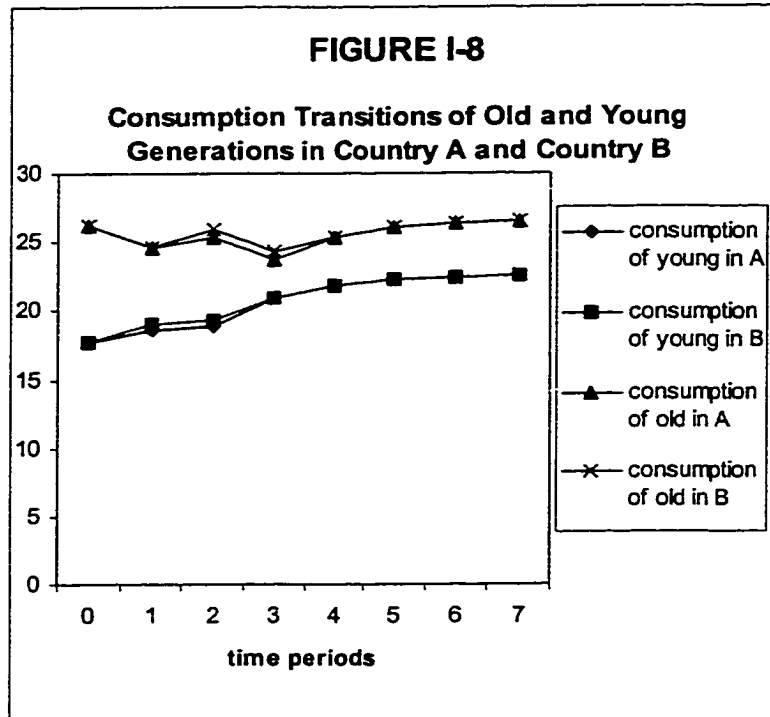


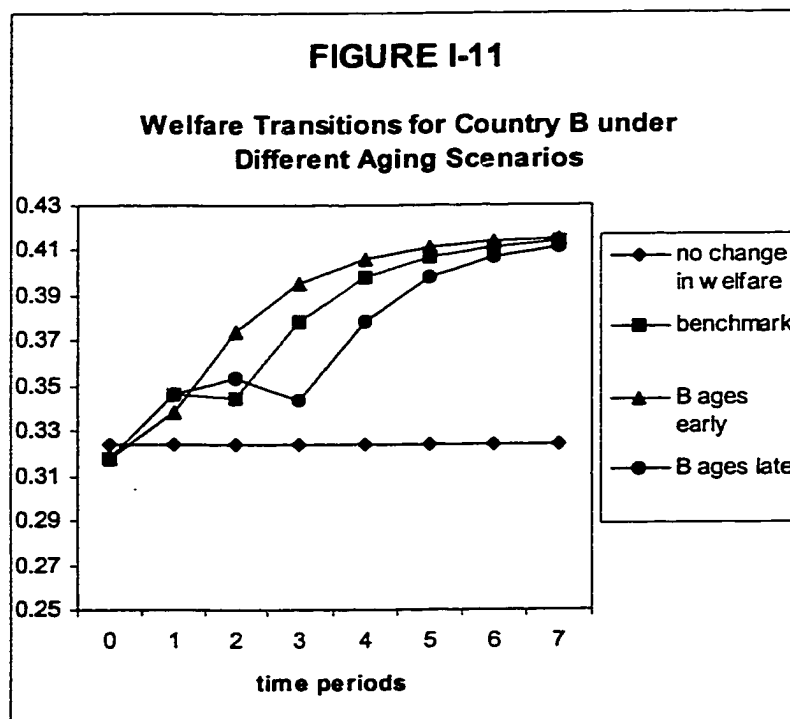
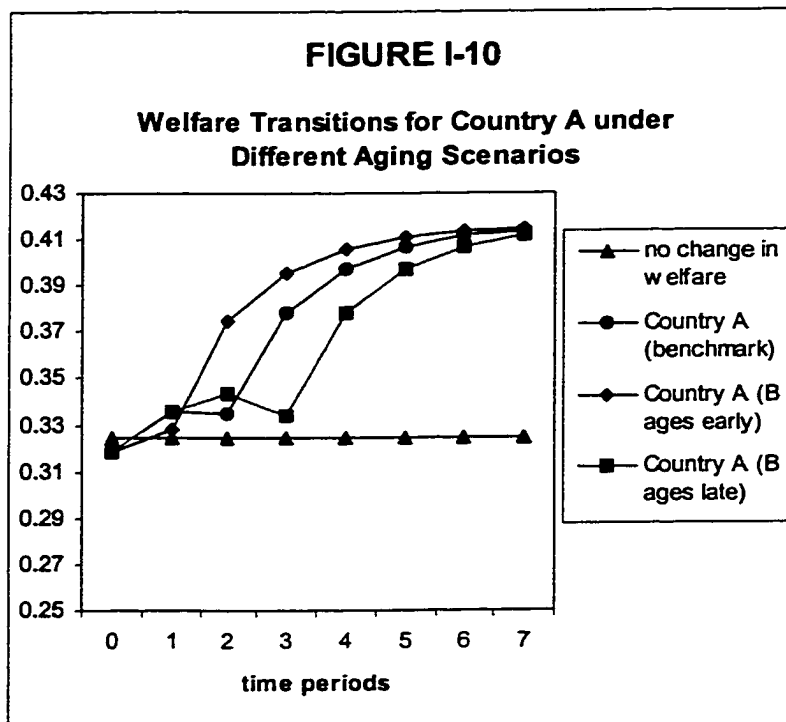
Source: Dependency ratios are computed by author. Population data is from Bos, Vu, Massiah and Vulatao (1994).

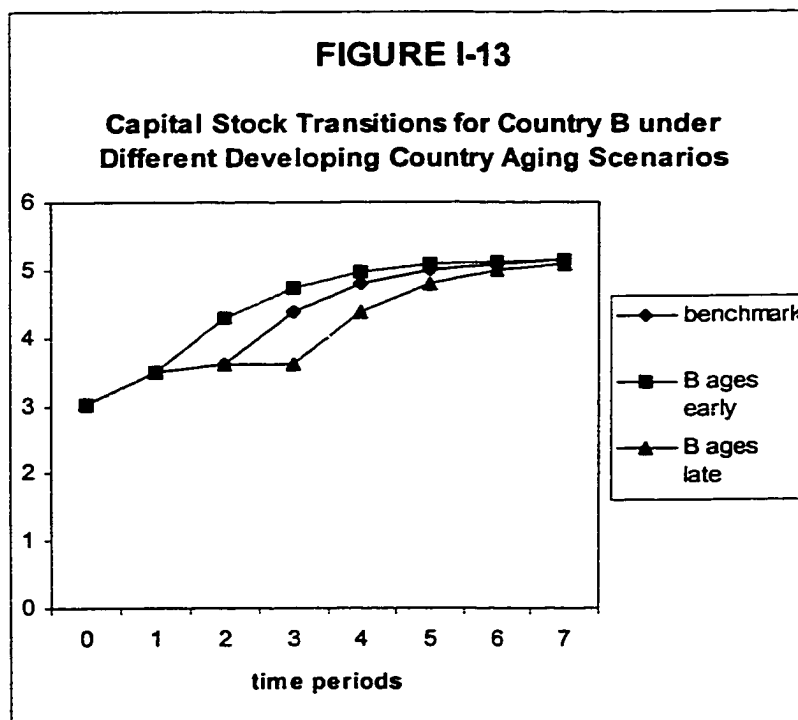
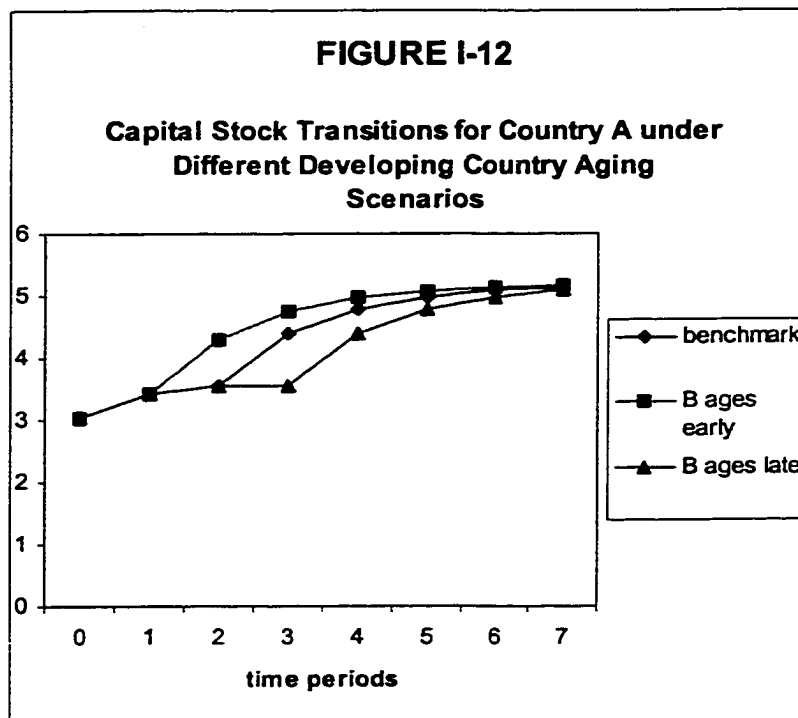












References

- Allais, M. 1947. *Economie et intérêt*. Paris: Imprimerie Nationale.
- Auerbach, A.J. and L.J. Kotlikoff. 1990. "Demographics, Fiscal Policy, and U.S. Saving in the 1980s and Beyond." In L.H. Summers (ed.), *Tax Policy and the Economy* 4. Cambridge, MA: MIT Press.
- Auerbach, A.J. and L.J. Kotlikoff. 1992. "The Impact of Demographic Transition on Capital Formation," *Scandinavian Journal of Economics*, 94(2): 281-295.
- Bearse, P., G. Glomm, and B. Ravikumar. 2000. "On the Political Economy of Means-Tested Education Vouchers," *European Economic Review*, 44: 904-915.
- Black, D. 1948. "On the Rationale of Group Decision-Making," *Journal of Political Economy*, 56: 23-34.
- Blanchard, O.J. 1985. "Debt, Deficits, and Finite Horizons," *Journal of Political Economy*, 93: 223-247.
- Börsch-Supan, A. 1996. "The Impact of Population Aging on Savings, Investment and Growth in the OECD Area." In *Future Global Capital Shortages: Real Threat or Pure Fiction?* Paris: Organisation for Economic Co-operation and Development, pp. 103-141.
- Bos, E., M.T. Vu, E. Massiah, and R.A. Bulatao. 1994. *World Population Projections*. Baltimore, MD: The Johns Hopkins University.
- Bös, D., and R.K. von Weizsäcker. 1989. "Economic Consequences of an Aging Population," *European Economic Review*, 33: 345-354.
- Buiter, W.H. 1981. "Time Preference and International Lending and Borrowing in an Overlapping Generations Model," *Journal of Political Economy*, 89(4): 769-797.
- Caldwell, S., M. Favreault, A. Gantman, J. Gokhale, T. Johnson, and L.J. Kotlikoff. 1999. "Social Security's Treatment of Postwar Americans." In L.H. Summers (ed.), *Tax Policy and the Economy*, 13. Cambridge, MA: MIT Press.
- Coronado, J.L., D. Fullerton, and T. Gloss. 2000. "The Progressivity of Social Security," NBER Working Paper No. 7250. Cambridge, MA: National Bureau of Economic Research.

- Cutler, D., J. Poterba, L. Sheiner, and L. Summers. 1990. "An Aging Society: Opportunity or Challenge," *Brookings Papers on Economic Activity*, 1: 1-73.
- Deardorff, A.V. 1994. "Growth and International Investment with Diverging Populations," *Oxford Economic Papers*, 46: 477-491.
- Diamond, P. 1965. "National Debt in a Neoclassical Growth Model," *American Economic Review*, 55: 1126-1150.
- Elmendorf, D.W., and L.M. Sheiner. 2000. "Should America Save for its Old Age? Fiscal Policy, Population Aging, and National Saving," *Journal of Economic Perspectives*, 14(3): 57-74.
- Feldstein, M.S., and C. Horioka. 1980. "Domestic Savings and International Capital Flows," *Economic Journal*, 90: 314-329.
- Gravelle, J.G. 1994. *The Economic Effects of Taxing Capital Income*. Cambridge, MA: The MIT Press.
- Harris, A.R., W.N. Evans, and R.M. Schwab. 2000. "Education Spending in an Aging America," Working Paper, Department of Economics. College Park: University of Maryland.
- Holtz-Eakin, D., M.E. Lovely, and M.S. Tosun. 2000. "Generational Conflict, Human Capital Accumulation, and Economic Growth," NBER Working Paper No. 7762. Cambridge, MA: National Bureau for Economic Research.
- Holtz-Eakin, D. 1993. "Demographics, Political Power and Economic Growth," *Public Finance*, 48 (Supplement): 349-365.
- Kahn, M.E. 2000. "Demographic Change and the Demand for Environmental Regulation," Working Paper, Department of Economics. New York: Columbia University.
- Kenc, T. and S. Sayan. Forthcoming. "Demographic Shock Transmission from Large to Small Countries: An Overlapping Generations CGE Analysis," forthcoming in the *Journal of Policy Modeling*.
- Laitner, J. 2000. "Simulating the Effect on Inequality and Wealth Accumulation of Eliminating the Federal Gift and Estate Tax," mimeo, Department of Economics. Ann Arbor, MI: University of Michigan.

- Masson, P.R. and R.W. Tryon. 1990. "Macroeconomic Effects of Projected Population Aging in Industrial Countries," *IMF Staff Papers*, 37(3): 453-485.
- Meijdam, L., and H.A.A. Verbon. 1996. "Aging and Political Decision Making on Public Pensions," *Journal of Population Economics*, 9: 141-158.
- Poterba, J.M. 1997. "Demographic Structure and the Political Economy of Public Education," *Journal of Public Policy and Management*, 16: 48-66.
- Samuelson, P.A. 1958. "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money," *Journal of Political Economy*, 66: 467-482.
- Taylor, A.M. 1996. "International Capital Mobility in History: The Saving-Investment Relationship," NBER Working Paper No. 5743. Cambridge, MA: National Bureau for Economic Research.
- Turner, D., C. Giorno, A. De Serres, A. Vourc'h, and P. Richardson. 1998. "Macroeconomic Implications of Ageing in a Global Context," OECD Working Paper AWP 1.2. Paris: OECD.
- Van Groezen, B., and T. Leers. 2000. "The Effects of Asymmetric Demographic Shocks with Perfect Capital Mobility," Working Paper, Department of Economics. Netherlands: Tilburg University.

Essay II

Generational Conflict, Fiscal Policy, and Economic Growth

1. Introduction

It is now widely understood that through a combination of lower fertility rates and longer life expectancies, most economies will “age” in the 21st century. The old-age dependency ratio (defined as the ratio of elderly persons to non-elderly adults) is forecast to increase by 75 percent between 1990 and 2040 in the United States, by 116 percent in Germany, and by 133 percent in Japan.¹ The phenomenon, however, is confined neither to the West, nor to rich countries. For example, the newly industrialized countries of Southeast Asia, which have relatively low initial dependency ratios, face a 128 percent increase in their average level of dependency.

The strain this transition will place on social security systems, and saving rates more broadly, has been well documented (for example, Cutler et al. 1990; Börsch-Supan 1992, 1996). In these studies, the neoclassical growth model is used to illustrate the “necessary” changes in saving and growth that policymakers should contemplate to address the demographic transition.²

However, demographic transition itself will likely alter public support for government programs, and thus endogenously alter fiscal policy. It is surprising that

¹See Börsch-Supan (1995).

the implications of an aging population for productivity-enhancing public programs has received less attention.³ For example, recent research has emphasized the important role of human capital in economic growth (see, e.g., Mankiw et al. 1992), the accumulation of which depends in part on public programs.⁴ Alternatively, social expenditure for basic research may be a key determinant of technological progress. In general, if the elderly do not support programs from which they do not directly benefit, it raises the possibility that demographic transition may undermine the level of public spending for a productivity-enhancing social infrastructure and, hence, harm long-run economic welfare.

Our goal is to examine the link between aging populations, old-age preferences for public programs, and economic performance. To focus squarely on the role of endogenous spending and the impact of aging, we base our analysis on a standard overlapping-generations model of economic growth. We use a simple median voter framework to represent the political process. In this context, a slowdown in the population growth rate raises the average age of the population and alters the level of public spending. In the interests of simplicity alone, we refer to the government spending program as “education,” and this certainly is one possible avenue for the

²Another strand of the literature looks at how different institutional arrangements alter the impact of population aging. Brueckner (1999), for example, studies the choice of fiscal federalism versus unitary government for long-run capital intensity and growth.

³A related literature investigates the effect of one form of endogenous policy—redistributive taxation—on growth (an extensive survey of which is provided by Persson and Tabellini 1994). A contrasting approach is taken by Wright (1996), who studies the effect of changes in an exogenous growth rate on fiscal choices. Wright suggests that the complex feedback between policy and growth may explain the conflicting results of the empirical literature, which contains instances of both positive and negative correlations between cross-country growth rates and government policy variables.

effects.⁵ However, we emphasize that our analysis applies to any social program whose direct effect is to raise the labor productivity of the working-age population.⁶ In the education example, the change in spending results in a change in the level of human capital, and affects the level of per-capita income.

The next section presents our modeling strategy and the derivation of individuals' policy preferences. The third section describes the political process and the outcome of majority voting. In the fourth section, we characterize the equilibrium and trace the evolution of the economy. Next we investigate the effects of demographic transitions on steady states in the model. In the sixth section, we simulate the steady-state effects; the seventh section presents simulations of the transitional dynamics. The final section contains concluding comments and suggestions for further research.

2. Modeling Strategy and Policy Preferences

We base our analysis on a conventional overlapping-generations model (Diamond 1965) in which individuals live for two periods. Each period, a cohort of size N_t is born, where $N_t = (1 + \eta)N_{t-1}$. The population at any point consists of the

⁴Our focus is on the provision decision. Alternatively, Bovenberg and van Ewijk (1997) study the impact of progressive taxation on human capital accumulation and long-run growth.

⁵For studies that focus on the political economy of education per se, see Epple and Romano (1996a, 1996b), Fernandez and Rogerson (1997, 1999), Glomm and Ravikumar (1992), Laitner (2000b), and Nechyba (2000). Poterba (1997) provides evidence that older individuals have a lower taste for education.

⁶There is a fairly large literature that emphasizes the political economy of social security (Bohn 1998, 1999; Cooley and Soares 1999a, 1999b; or Boldrin and Rustichini 2000). Our analysis focuses less on intergenerational transfers and more on outlays that directly affect productivity.

“old” and the “young” and, thus, is of size $N_t + N_{t-1}$. Note that η determines both the growth rate of the total population and the ratio of old to young, which equals $\frac{1}{1+\eta}$.

Demographic transition is introduced as a decrease in η that raises the dependency ratio.

We focus our discussion of fiscal policy on a single type of government spending financed by a flat income tax on the labor income of the young and the capital income of the old. To highlight the possibility for generational conflict, we posit that the public good enhances the productivity of labor. There is no consumption demand for the public good per se; demand derives solely from its effect on the income of the young. Moreover, there are no deliberate transfers from the old to the young or *vice versa*. With these modeling choices, there is no gain in utility for the currently old cohort from the provision of public services to the young and generational conflict is maximized.⁷

The conventional overlapping-generations framework provides a rather sterile theory of public choice: the young will all want the same, positive level of the publicly provided good while the old will want none. A median-voter representation of the political process leads to a simple counting of generational size. With positive

⁷Notice that despite our use of the term “dependency ratio,” our model does not contain explicit provision of old-age consumption via government programs (e.g., Social Security). Meijdam and Verbon (1996), in contrast, analyze the effect of aging on the political decision making for public pensions in an overlapping-generations model. As in the current paper, they find that with growth an increase in the political power of the old may not alter fiscal choices in the direction expected in the absence of growth. Kaganovich and Zilcha (1999) study the effect of various allocations of tax

population growth, the young will always outnumber the old, the young will always determine the political outcome, and (because the young are identical), there will be a single level of human capital.

To address these shortcomings, we posit a distribution of abilities within each generation.^{8,9} The ability of individuals ranges from 0 to 1, and the density function of abilities for each generation is denoted by $f(a)$. By definition, the density function satisfies $\int_0^1 f(a) da = 1$. As described below, high-ability individuals benefit more (acquire more human capital) from a given amount of government spending than do low-ability individuals. Thus, the economy will display a distribution of human capital and income. For this reason, the distribution of ability leads to a distribution of preferred spending levels.¹⁰

Turning to specifics, each individual is assumed to have a lifetime utility function given by:

$$U = \ln c_{jt} + \left[\frac{1}{1+\delta} \right] \ln c_{jt+1}, \quad (1)$$

revenues to education and social security benefits on growth. Their model does not, however, permit this allocation to be endogenously determined.

⁸We assume that the distribution of abilities is the same in all generations so as not to confound the effect of changes in *size* of generations (demographic shift) with changes in the *composition* of generations.

⁹An alternative strategy is to model the life cycle using three (or more) periods. This approach permits richer life-cycle profiles for earnings and demands for public programs. It comes at the expense, however, of clarity and tractability, and does not alter the basic analysis of demographic pressures.

¹⁰Holtz-Eakin (1993), in an overlapping-generations framework, obtains a distribution of preferences for a publicly provided good by introducing the possibility that not all individuals born at time t survive to time $t+1$. This assumption generates “accidental bequests” inherited by members of the next generation and induces a distribution of incomes within the younger generation.

where c_{jt} is consumption of a member of generation j when young, $c_{j,t+1}$ is consumption when old, and δ is the pure rate of time preference.¹¹ When young, the individual supplies one unit of “time” to the economy. However, “effective” labor units (e) are dependent upon a_i , the ability level of individual i . That is, effective labor is $e_i(a_i)$.¹² Labor income is thus $w_t e_i(a_i)$, where w_t is the wage at time t . The individual pays taxes on labor income and capital income at the rate τ_t . Given these arrangements, the young person of ability a_i is faced with a budget constraint of the form:

$$c_{jt}(a_i) + s_{jt}(a_i) = \theta_t w_t e_i(a_i), \quad (2)$$

where $\theta_t = (1 - \tau_t)$ and s_{jt} is first-period saving. Old-age consumption is financed by saving:

$$c_{j,t+1}(a_i) = (1 + r_{t+1} \theta_{t+1}) s_{jt}(a_i), \quad (3)$$

where r_{t+1} is the return to capital in the economy. Effective labor units are also dependent upon human capital acquisition. We assume that the productivity effects depend on the interaction of ability and productivity-enhancing expenditures by the government (“education”). The production function for human capital shows the dependence of human capital acquired on the interaction of ability and educational spending:

¹¹Our choice of logarithmic utility simplifies the analytics, but does not affect our substantive findings. We return to this in our sensitivity analysis below.

$$e_i(a_i) = A_H [a_i g_i + 1]^\psi, \quad (4)$$

where A_H is an efficiency index, and $e_i(a_i)$ is the human capital acquired by a person of ability level a_i when provided with g_i of education spending per young person.¹³

To rule out increasing returns in public service provision, we restrict the value of ψ to be less than unity. The form of (4) ensures that individuals of the lowest ability ($a_i = 0$) provide some productive labor to the economy and that higher ability individuals provide an amount dependent on their own ability level and g_i .

The young maximize (1) subject to (2), (3), and (4). Taking g_i as given, the first order condition for the choice of c_{jt} is:

$$c_{jt}(a_i) = (1 + \delta)s_{jt}(a_i). \quad (5)$$

Using equation (5) and the budget constraint, the optimal saving of a young person in generation j is given by:

$$s_{jt}(a_i) = \left[\frac{1}{2 + \delta} \right] \theta_t w_t e_i(a_i), \quad (6)$$

which does not depend on fiscal policy in future periods.¹⁴ Corresponding to the saving function are the consumption functions:

¹²In the context of our model, allowing an endogenous allocation of time between “schooling” and supplying labor does not change our analysis. All young workers, regardless of ability, will choose to allocate the same proportion of time to supplying labor.

¹³We assume education services are equally distributed among all ability types, as in Epple and Romano (1996b). Equal division introduces a distortion in that the marginal product of educational services are not equalized across young people of different abilities. We return to this below.

¹⁴This is a direct result of our choice of logarithmic utility, and greatly simplifies the analytics. We relax this restriction in our simulation analysis.

$$c_{jt}(a_i) = \left[\frac{1+\delta}{2+\delta} \right] \theta_t w_t e_t(a_i); \quad (7)$$

$$c_{j,t+1}(a_i) = \left[\frac{1+r_{t+1}\theta_{t+1}}{2+\delta} \right] \theta_t w_t e_t(a_i). \quad (8)$$

Thus far, fiscal policy has been taken as given. However, each member of the young generation will have a preferred policy mix that balances the benefits of spending with the tax-associated costs. To characterize this preferred policy, we substitute the consumption functions (7) and (8) into the utility function (1), yielding the indirect utility function

$$\begin{aligned} V_t(a_i) = & \ln(1+\delta) - \frac{2+\delta}{1+\delta} \ln(2+\delta) + \frac{2+\delta}{1+\delta} [\ln \theta_t + \ln w_t + \ln e_t(a_i)] \\ & + \frac{1}{1+\delta} \ln(1+r_{t+1}\theta_{t+1}). \end{aligned} \quad (9)$$

We assume that each voter views herself as small relative to the economy, and thus takes w_t , r_{t+1} , and θ_{t+1} as given. As a result, the preferred value of τ_t will maximize current after-tax income, subject to the government budget constraint, $\tau_t y_t = g_t$, where y_t is income per young person, which is also taken as given by an individual voter.

This preferred tax rate is

$$\tau_{jt}(a_i) = \frac{a_i \psi y_t - 1}{(1+\psi) a_i y_t}. \quad (10)$$

Note that the preferred tax rate depends directly only upon the current level of aggregate income per worker and the individual's ability.¹⁵ It is straightforward to verify that $\tau_{jt}(a_i)$ is increasing in a_i . Also, higher-ability individuals will have higher individual incomes. In addition, higher-ability individuals receive a disproportionately higher marginal value of additional spending. Combining these two effects, (10) implies a positive income elasticity for the preferred tax rate.

Decision making by the old is trivial. They receive no benefits, but face taxes on capital income from their first-period saving. As a result, every member of the old generation has the same preferred tax rate of

$$\tau_{j-1,t} = 0. \quad (11)$$

Note that older voters do not incorporate general-equilibrium impacts on the return to capital into their voting strategies, a result consistent with our assumption that each voter is small relative to the economy.

3. The Political Process

Following a long tradition dating to Black (1948), we adopt a median-voter approach to public choice. The median-voter model is appropriate in the context of our model for several reasons. First, the choice facing voters is over a single dimension and voters' preferences have a single peak. Thus, it is possible to define a median voter. Second, in the context of the overlapping generations model, our use of

¹⁵It is useful to note that the solution for the preferred tax rate is the same for all utility

the median voter model in effect assumes only that over relatively long periods the public sector is responsive to voter preferences. It need not rule out short-run rigidities, bureaucratic agency problems, or monopoly power that are important aspects of criticisms of the median-voter model.¹⁶

The median voter is that voter whose preferred tax and spending policy would win a majority of votes against any other feasible alternative. To win a majority, a proposed fiscal combination must achieve votes equal to $(N_{t-1} + N_t)/2$. Because the preferred tax rate of the old is zero, there will be N_{t-1} voters who will always prefer the smaller of two proposed tax rates.¹⁷ Among the young, those with lesser ability prefer a lower tax rate than those with greater ability. Thus, the median voter, denoted by her ability level a_m , is defined by

$$N_{t-1} + N_t \int_0^{a_m} f(a) da = \frac{N_{t-1} + N_t}{2}. \quad (12)$$

Given a value for a_m , the actual budget and spending policies of the economy may be calculated using (10) and the government budget constraint. The tax and spending values that determine consumption, saving, and human capital accumulation are those of the median voter.

functions of the constant relative risk-aversion form. In particular, our solution is not specific to logarithmic preferences.

¹⁶See Romer and Rosenthal (1983) for an overview of the model's uses and limitations.

¹⁷Note that it is not important that the preferred tax rate of the older generation be exactly zero. In practice some older voters will have a positive preferred spending level. For purposes of solving the model, however, assuming that individuals follow only their narrow economic self-interest makes it easy to identify the median voter precisely and solve the political-economic equilibrium easily.

4. Production, Equilibrium, and Dynamics

Total output in the economy is governed by the production function

$$Y_t = A_Y K_t^\alpha H_t^{1-\alpha}, \quad (13)$$

so that output per young person is

$$y_t = A_Y k_t^\alpha h_t^{1-\alpha}, \quad (13')$$

where A_Y is a productivity index, and lower-case quantities are per young person, *i.e.*,

$k_t = K_t / N_t$ and $h_t = H_t / N_t$. Total human capital depends on government spending

and the distribution of ability. The aggregate supply of human capital is defined as

$$H_t = N_t \int_0^1 e(a) f(a) da. \quad (14)$$

Using (4), human capital per young person is

$$h_t = A_H \int_0^1 [ag_t + 1]^\psi f(a) da. \quad (15)$$

Given levels of human capital, labor is supplied inelastically and the labor market clears when the wage is equal to the marginal product of labor

$$w_t = (1 - \alpha) A_Y \left[\frac{k_t}{h_t} \right]^\alpha. \quad (16)$$

Similarly, equilibrium in the market for capital inputs occurs when the real rental price of capital equals the marginal product of capital

$$r_t = \alpha A_Y \left[\frac{k_t}{h_t} \right]^{\alpha-1}. \quad (17)$$

Because of differences in human capital within a generation, supplies of capital (saving) differ across individuals. Aggregating individual saving (6) using the human capital supply function (15), saving per young person is

$$s_t = \left(\frac{1}{2 + \delta} \right) \theta_t w_t A_H \int_0^1 [a g_t + 1]^\psi f(a) da. \quad (18)$$

Capital market equilibrium requires

$$k_{t+1} = \frac{s_t}{1 + \eta}. \quad (19)$$

Combining (18) and (19), capital per young person evolves according to¹⁸

$$k_{t+1} = \left[\frac{1}{(1 + \eta)} \right] \left[\frac{1}{2 + \delta} \right] \theta_t w_t A_H \int_0^1 [a g_t + 1]^\psi f(a) da. \quad (20)$$

As can be seen directly from equation (20), fiscal policy choices (θ_t, g_t) have an important influence on the evolution of capital in the economy. Moreover, the evolution of the economy itself affects the adopted tax policy, as equation (10) shows that the preferred tax rate of any individual depends on income per person. These dynamics are potentially quite complicated, but our choice of logarithmic preferences makes it possible to describe analytically the effects of population aging on the steady state of the economy. Once we have examined these steady-state effects, we use numerical simulations to gauge the sensitivity of our steady-state analysis to different values for several key parameters. We also employ numerical simulations to trace out

¹⁸In a related model, Glomm and Ravikumar (1995) show that the overlapping-generations model may yield multiple equilibria. Our choice of utility function eliminates this possibility.

the transition path between steady states that results from a rise in the dependency ratio.

5. Steady State Implications of Demographic Transition

As in the conventional overlapping generations model, the steady state is characterized by $k_{t+1} = k_t$. It is straightforward to verify that this equality simultaneously implies constant values for human capital per worker, income per worker, education spending per young person, preferred tax rate of the median voter, and ability of the median voter. The steady state will be disrupted by a demographic transition, i.e., by a decrease in η . To see how a decrease in η alters the steady state, we begin by differentiating (12) to show that the ability of the median voter will fall:

$$\frac{d a_m}{d \eta} = \frac{1}{2} \frac{1}{(1+\eta)^2} \frac{1}{F'(a_m)} > 0. \quad (21)$$

The location of the median voter in the ability distribution changes because when η decreases the number of old people relative to the number of young people rises. With relatively more old voters, a majority can be formed with fewer young voters, and the median voter becomes a person with a lower ability. Note that as a consequence, the median voter's preferred tax rate will immediately be lower, even at the income level of the initial steady state.

To pursue further analytic solutions for the effect of a decrease in η on the steady state of the economy, we are forced to choose a specific distribution for ability. Thus, we assume that ability among the young follows a uniform distribution. While

the uniform distribution is special, the key insights of the model do not depend on it. As we have just shown, a decrease in the population growth rate creates a median voter with a lower ability. Therefore, regardless of the ability distribution, the tax rate chosen (at any given average income level) will be lower when the population grows more slowly. It is this reduction in desired tax rates, rather than the specific ability distribution, that produces our key results.

Steady-State Comparisons

The condition for capital market equilibrium holds in both the initial and the post-transition steady state. Noting that $k_t = k_{t+1}$ in the steady state and denoting steady-state values by the absence of time subscripts, total differentiation of (19) yields,

$$\hat{k} = \hat{s} - (\widehat{1 + \eta}), \quad (22)$$

where $\hat{x} = dx/x$ indicates the proportionate change in a steady-state value. Saving per young person is given by (18), which can be totally differentiated to yield

$$\hat{s} = \hat{w} + \hat{h} - \Delta \hat{\tau}, \quad (23)$$

where $\Delta = \tau/(1 - \tau)$. The change in human capital depends on the adjustment in steady-state education spending. Recalling our assumption that the ability distribution follows a uniform distribution, and integrating (15), human capital per worker is

$$h_t = \frac{A_H}{(\psi + 1)g_{mt}} \left[(1 + g_{mt})^{\psi+1} - 1 \right], \quad (24)$$

where g_m is the level of spending preferred by the median voter at time t . Totally differentiating and evaluating at the steady-state,

$$\hat{h} = \varepsilon_{hg} \hat{g}_m, \quad (25)$$

where ε_{hg} is the elasticity of human capital per worker with respect to government education spending.¹⁹ Government budget balance restricts the change in the steady-state level of spending:

$$\hat{g}_m = \hat{\tau}_m + \hat{y}. \quad (26)$$

The change in steady-state spending must also conform to the new political equilibrium. Differentiating the expression for the median voter's preferred tax rate (10),

$$\hat{\tau}_m = \varepsilon_{\tau a} \hat{a}_m + \varepsilon_{\tau y} \hat{y}, \quad (27)$$

where the elasticities of the preferred tax rate with respect to ability and income are:

$$\varepsilon_{\tau a} = \varepsilon_{\tau y} = \frac{1}{a_m \psi y - 1}, \quad (28)$$

and these elasticities are positive for positive τ . Finally, turning to steady-state production, differentiation of (13) yields

$$\hat{y} = \alpha \hat{k} + (1 - \alpha) \hat{h}. \quad (29)$$

¹⁹Given the form (4) for the relationship between human capital and educational spending,

$$\varepsilon_{hg} = \frac{1}{[(1 + g_m)^{\psi+1} - 1]} \left[(\psi g_m - 1)(1 + g_m)^\psi + 1 \right].$$

The change in the wage also depends on adjustments to physical and human capital; using (16),

$$\hat{w} = \alpha(\hat{k} - \hat{h}). \quad (30)$$

Demographic Transition Without Endogenous Politics

Since we wish to highlight the importance of endogenous policy, it is useful to establish as a baseline the effect of demographic transition without politics. Thus, we begin by deriving the effect of a change in η on the steady-state capital stock and income, assuming that the level of education spending per young person remains fixed.²⁰

Because g is fixed, the level of human capital is fixed. Consequently,

$$\hat{y} = \alpha \hat{k}. \quad (31)$$

Also, by assumption, the tax rate is affected only by income changes that make it easier or harder to finance g :

$$\hat{\tau} = -\hat{y}. \quad (32)$$

Noting that wages grow at the same rate as income, and using (22), (23), (31) and (32),

$$\hat{k} = -\frac{1}{1 - \alpha(1 + \Delta)}(\widehat{1 + \eta}). \quad (33)$$

²⁰Alternatively, we could fix the tax rate. However, because inefficiencies derive from choosing a suboptimal value of g and not from tax-based distortions, it is more instructive to fix g .

Stability of the intertemporal equilibrium requires $1 > \alpha(1 - \Delta)$ so a decrease in η leads the economy to a steady state with a higher level of capital per worker.²¹ In keeping with this result, steady-state income per young person, consumption, and the wage also rise. This is a well-known result from the conventional neoclassical growth model. Lower population growth reduces break-even investment, the amount of investment necessary to keep k constant, without affecting saving at any given level of capital. Public finance matters only in that the tax rate affects the slope of the saving function.

Demographic Transition With Endogenous Politics

Recognizing individuals' political incentives broadens the effect of demographic transition to encompass tax rate changes for reasons other than those due to national income. Slower population growth reduces the tax rate preferred by the median voter, *ceteris paribus*, leading to changes in government outlays and human capital. Feedbacks via physical capital will, in turn, further influence the political equilibrium.

Changes in the steady-state capital per worker derive from changes in after-tax income and changes in the number of workers. Using (22) and (23),

$$\hat{k} = \hat{w} + \hat{h} - \Delta\hat{\tau} - \widehat{(1 + \eta)}. \quad (34)$$

Substituting using equations (25) to (27), and (29) and (30) yields the quasi-reduced form expression,

²¹See the Appendix.

$$\hat{k} = \frac{((1-\alpha)\varepsilon_{hg} - \tau)M_K}{1-\tau} \varepsilon_{\tau\alpha} \widehat{a_m} - \frac{M_K}{M_Y} (\widehat{1+\eta}), \quad (35)$$

where

$$M_Y = \frac{1}{1 - (1-\alpha)\varepsilon_{hg}(1 + \varepsilon_{\tau y})}, \quad \text{and}$$

$$M_K = \frac{1}{(1-\alpha)(1 - \varepsilon_{hg}(1 + \varepsilon_{\tau y})) + \alpha\Delta\varepsilon_{\tau y}}.$$

Local stability of the political equilibrium requires $M_Y > 0$ while local stability of the intertemporal equilibrium requires $M_K > 0$.²²

To gain a feel for the importance of endogenous political responses, consider first the case in which the ability of the median voter, a_m , is fixed, but government spending is not. That is, due to changes in the economic steady state, the same pivotal voter alters the demand for government spending. Looking at the second term on the right side of (35), we see that a decrease in population growth raises steady-state capital per worker, holding a_m fixed.²³

What lies behind this result? M_Y is the multiplier effect of an autonomous increase in output (say due to a productivity change or shift in A_Y) on steady state output, while M_K is the corresponding multiplier effect of a windfall of capital on steady-state capital per worker. Consequently, the coefficient on $(\widehat{1+\eta})$ in (35) is the effect of an initial increase in capital per worker (due to a decrease in the size of the

²²See the Appendix.



working population) on income and the effect of this rise in income on capital accumulation.²⁴

As noted above, however, a decrease in η changes the identity of the median voter to that of a lower ability person. This voter-identity effect has an indeterminant influence on steady-state capital per worker, as can be verified by looking at the coefficient on $\widehat{a_m}$ in (35), where the effect depends on the sign of $(1 - \alpha)\epsilon_{hg} - \tau$.

To see why the effect is ambiguous, consider a social planner who is constrained to offer the same amount of education to everyone, regardless of ability. This constrained social optimum is characterized by the first order condition

$$(1 - \alpha)\epsilon_{hg} = \tau. \quad (36)$$

The planner chooses a level of spending that equates the marginal benefit of education, measured as its proportionate impact on income, $(1 - \alpha)\epsilon_{hg}$, with its marginal cost, also measured as its proportionate impact on income, τ . The coefficient on a_m can be interpreted in this light. If the median voter initially chooses spending on education that is “too high,” the coefficient will be negative, and a reduction in the median voter’s ability will raise capital per worker in the steady state. Effectively, the decline in a_m will reign in inefficient spending—that spending whose marginal contribution to total income is less than its marginal cost in terms of lost

²³A comparison of equations (35) and (33) shows that only when $\epsilon_{hg} = 0$ and $\epsilon_{\tau\eta} = -1$, will the effect be identical to the exogenous politics case.

consumption. On the other hand, if spending is initially “too low,” the decrease in the median voter’s ability exacerbates the inefficiency, reducing income, saving, and capital per worker in the steady state.

The median voter’s choice can be compared to the social planner’s choice by noting that the median voter chooses τ to maximize her after-tax income. The first-order condition guiding the median voter can be expressed as

$$(1 - \tau)\varepsilon_{hg}^m = \tau, \quad (37)$$

where ε_{hg}^m is the elasticity of the median voter’s human capital with respect to education spending. In comparing this condition to (36), we notice two differences. First, the planner chooses public spending to maximize national income rather than after-tax income. Secondly, the average effectiveness of education in raising human capital, ε_{hg} , differs from its impact on the median voter, ε_{hg}^m .

Even if capital per worker is higher in the new steady-state, however, there is no assurance that income per worker will rise, as human capital per worker may fall when a lower tax rate is chosen. A useful reduced form expression for the change in education spending is:

$$\hat{g} = M_Y \left[\varepsilon_{ta} \hat{a}_m + \alpha(1 + \varepsilon_{ty}) \hat{k} \right]. \quad (38)$$

Because ε_{ta} is positive, as is M_Y , a reduction in the median voter’s ability may result in lower steady-state government spending despite an increase in capital per worker.

²⁴It can be shown that a larger response of human capital to government spending (a larger

Consequently, human capital per worker may fall and the economy's human-to-physical capital ratio may fall.

The change in steady-state income per worker depends on the change in h and k , and may be expressed as:

$$\hat{y} = M_Y \left[(1-\alpha)\varepsilon_{hg}\varepsilon_{\tau a}\hat{a}_m + \alpha\hat{k} \right]. \quad (39)$$

The coefficient on $\hat{a}_m$ is positive, so a fall in the median voter's ability may reduce income even when it raises steady-state capital per worker. This immiserizing outcome is more likely to occur, for a given $\hat{k}$, the larger are the elasticities ε_{hg} and $\varepsilon_{\tau a}$ and the larger is labor's share of national income, $(1-\alpha)$. It can be shown that $\varepsilon_{\tau a}$, the response of the preferred tax rate to a change in ability, is smaller the larger is ψ . Ceteris paribus, the more effective public education is in raising human capital (defined as larger ψ), the smaller the decrease in the equilibrium tax rate resulting from the demographic transition.

A more effective education system, however, also implies a larger loss in human capital as a result of the decrease in τ precipitated solely by the fall in voter ability. The elasticity ε_{hg} is larger for a larger ψ , so holding $\varepsilon_{\tau a}$ constant, a larger ψ makes it more likely that a decline in the population growth rate is immiserizing.

Labor's share of national income also determines the income loss from a shift in the median voter. The larger this share is, the more a decrease in human capital

ε_{hg}) implies a larger response of steady-state capital to a change in η if $(1-\tau) > \tau\varepsilon_{\eta\tau}$. This condition

reduces national income. In simulations described below, we characterize the combinations of α and ψ that produce an immiserizing outcome.

6. Simulation Methods and Steady-State Sensitivities

To better understand the implications of the model, we use numerical simulations to gauge the sensitivity of our steady-state analysis to values for key parameters. We also undertake a series of numerical simulations to investigate the dynamics of transition between steady states. A necessary price of doing so, however, is that we must adopt specific functional forms and parameters for our model.

To begin, we set δ equivalent to an annual rate of time preference of 4 percent.²⁵ Under the crude assumption that one “period” in the model equals 30 years, the 4 percent rate of time preference translates into a value of δ equal to $(1.04)^{30} - 1 = 2.24$. Alternatively, $1/(1.04)^{30} = 0.308$ is the rate at which the future is discounted in the model.

We begin with the assumption that the population growth rate (η) is 2.0 percent annually, a bit more rapid than the recent United States experience. This annual rate corresponds to growth of 81.1 percent over a model period. In the context of the model, η serves as well as the key parameter for analyzing generational shifts. The ratio of the old to young generations is given by $1/(1+\eta)$; in our base case, this is equal to 0.55. We investigate the dynamics resulting from a shift in the population

restricts the effect of higher government spending on after-tax income to be positive.

growth rate from 2.0 percent (annually) to 1.0 percent. Thus, in the model the dependency ratio rises to 0.74, an increase of roughly 35 percent. We assume that ability, a , is distributed uniformly in the interval $[0,1]$.²⁶ Finally, we set the elasticity of output with respect to capital input equal to one-third ($\alpha = 0.33$).²⁷

We do not constrain ourselves to a particular value of ψ . Instead, Table II-1 summarizes our comparative steady-state results for a range of values for ψ , the elasticity of human capital output with respect to inputs of ability and government spending.²⁸ Entries in the first column serve as our “exogenous policy” baseline. They are derived by holding government spending fixed when the population growth rate is reduced. Looking at the results, the tax rate always declines, capital per worker always grows, and income per worker always grows regardless of the value chosen for ψ . The decline in the tax rate varies only slightly as ψ increases, reflecting only ψ 's effect on average income.

In contrast, consider column (2) in which government spending is determined by a median voter. Here, a larger value for ψ has a direct effect on the desired amount of government spending. The tax rate falls dramatically for low values of ψ , but actually falls by less than the exogenous policy case for high values of ψ . Indeed,

²⁵See Coronado, Fullerton, and Glass (2000) for a discussion of discount rates in the context of Social Security analysis.

²⁶The uniform distribution is appealing for its tractability, but does not provide a realistic distribution of post-education earnings (which display a log-normal distribution). Thus, an extension for future research is the use of alternative specifications of the ability distribution.

²⁷Laitner (2000a) argues that $\alpha = 0.33$ is consistent with recent United States data.

for high enough ψ , as shown by the results for $\psi=0.5$, government spending and human capital actually rise even though the tax rate falls. At lower values of ψ , steady-state capital per worker and income per worker rise even though human capital falls. For the value $\psi=0.32$ (and below), however, the decline in human capital is so severe that income per worker declines even though capital increases. The low ψ value implies a large ϵ_{ω} and, thus, a large decline in government spending when the ability of the median voter falls. This case illustrates the possibility of immiserizing demographic transition stemming from the endogenous response of public spending.²⁹

The critical value of ψ , above which income per worker rises, depends on the share of labor income in national income $(1-\alpha)$. In Figure II-1, for a range of values for α , we trace out the critical value of ψ above which a decline in the population growth rate raises income per worker. This relationship is non-linear in general, but for $\alpha > 0.33$ the value of ψ needed to ensure income growth is increasing in α .

²⁸Laitner (2000b) uses a similar function to examine the distribution of labor earnings in a growth context. Although the particulars differ, the implied elasticity of human capital with respect to education spending in our base specification, 0.4, is close to his preferred elasticity.

²⁹In Appendix Table II-1, we investigate the same relationship using a utility function exhibiting constant relative risk aversion (CRRA) rather than the logarithmic form. The constant relative risk aversion form used is

$$U = \frac{1}{1-\gamma} c_t^{1-\gamma} + \frac{1}{1+\delta} \frac{1}{1-\gamma} c_{t+1}^{1-\gamma}$$

where γ is set to 0.5. Other values of γ produced similar results. The results here are largely the same, except that the population decline is immiserizing for a higher cut-off value of ψ . Again, we see the decline in tax rate depends on the elasticity ϵ_{ω} , which is larger for smaller values of ψ .

values.³⁰ This relationship reflects the lower income payoff from additional government spending when labor's share $(1 - \alpha)$ is low and thus the need for a smaller human capital response from the decline in median voter ability to prevent an immiserizing outcome.

7. Transition Paths

Of course, comparative steady states may provide a misleading picture of the actual events that transpire during the process of demographic shift. To shed light on the dynamics, Figures II-2 through II-5 depict the transition paths obtaining for a case in which the demographic transition leads to higher steady-state income, specifically for $\psi = 0.5$.³¹

Figure II-2 translates the political logic of steady states directly to the transition period. In response to the shift, the ability level of the median voter declines and remains unchanged. The level of spending preferred by the median voter, however, initially declines but rises gradually as income per worker rises. Indeed, eventually education spending is higher than in the case of a fixed level of government spending. As shown in Figure II-3, the level of human capital per worker mimics this pattern, dropping precipitously in the first period and rising so that it exceeds the fixed- g case. The dynamic path of human capital follows from the rapid growth in economic activity (Figure II-4) generated by accumulation of physical (Figure II-5)

³⁰This nonlinearity comes from the influence of ψ and α on the product $M_Y \epsilon_{hg} \epsilon_{\alpha}$.

capital. Thus, while we find poorer economic performance during the very early periods of transition, the model suggests that endogenous formulation of fiscal policy may provide for a compensating boost in growth that raises income per worker. As we discussed above, however, the long-run effect of the population shift depends on both the value of ψ (the effectiveness of government spending in raising productivity) and on the degree to which the initial conditions are characterized by an inefficiently large (or small) public sector.

8. Conclusions

As dependency ratios increase over the next 50 years there will be corresponding shifts in the political pressures that determine fiscal policy. Accordingly, the degree to which a more elderly population will support public spending on productivity-enhancing programs is of particular interest. In the context of a median-voter model of the political process, embedded within an overlapping-generations model of economic growth, we have shown that there is no automatic link between the preference for lower spending by older individuals and either the long-run scale of programs for young workers, or economic performance. Instead, when the demographic transition alters the identity of the median voter, the resultant political and economic dynamics will exacerbate under-provision if the public sector is inefficiently small. However, it is also possible that such a shift may trim an

³¹The transition paths look similar for a CRRA utility function and the same ψ value.

inefficiently large government, reduce tax rates and raise capital per worker enough to raise the long-run level of spending per worker.

Our findings highlight the importance of three issues for future research. First, a key parameter in our model is the mapping between government inputs and the productivity of workers, making clear the value of additional research in this area. Second, our model focuses on the provision of public spending at the expense of a detailed description of the financing structure. To the extent that non-neutral income taxes and other financing schemes alter the incentives to acquire human capital, it would be useful to embody these effects in future research. Finally, our results are derived in the context of a closed economy. In the presence of internationally mobile capital, two additional features may be important. To begin, capital will flow internationally in pursuit of the highest return, altering the dynamics of capital accumulation. However, the simultaneous aging of other countries will induce political pressures for altered fiscal policies and capital flows across the globe.

Appendix: Stability Analysis

Stability of the Political Equilibrium

Analysis of the stability of the political equilibrium obtaining in any given period allows us to sign the term M_Y in the text. The political equilibrium is defined to be locally stable if, starting from a given level of g , the economy moves automatically to an equilibrium. To analyze stability, we posit a Marshallian-type adjustment rule for government spending of the form

$$\dot{g} = c \left[\frac{\tau_p}{\tau} - 1 \right] = \varphi(g), \quad (\text{A.1})$$

where the c is a positive constant and the dot above a variable represents its time derivative. The variable τ is the actual tax rate, as necessitated by the government budget constraint. It is a function of g and the contemporary level of income per young person. The variable τ_p is the tax rate desired by the median voter at the given level of education spending and income. The rationale behind (A.1) is that education spending will increase if the desired tax rate exceeds the actual tax rate needed to balance the government's budget. The equilibrium level of spending, $\bar{g}$ solves $\varphi(\bar{g}) = 0$. $\bar{g}$ is locally dynamically stable if and only if $\varphi'(\bar{g}) < 0$.

Using (25), (27), and (29) and noting that within a generational period the capital stock is given,

$$\hat{\tau}_p = (1 - \alpha) \varepsilon_{hg} \varepsilon_{vy} \hat{g}, \quad (\text{A.2})$$

where the elasticities are defined in the text and $\hat{x}$ is defined as $\dot{x}/x$. Rearranging the differentiated government budget constraint and using (25) and (29), the actual tax rate changes according to:

$$\hat{\tau} = [1 - (1 - \alpha)\varepsilon_{hg}] \hat{g}. \quad (\text{A.3})$$

Differentiating (A.1) and using (A.2) and (A.3), stability of the political equilibrium requires that

$$\phi'(\bar{g}) = (1 - \alpha)\varepsilon_{hg}(1 + \varepsilon_{\tau y}) - 1 < 0. \quad (\text{A.4})$$

Condition (A.4) implies that M_y , as defined in the text, is positive if the within-generation political equilibrium is stable.

Intertemporal Stability with Endogenous Politics

With Cobb-Douglas production technology and logarithmic preferences, the evolution of the capital stock is a function of the contemporaneous tax rate, wage, and human capital level. Since the tax rate, wage, and human capital level are functions of the contemporaneous capital stock, the evolution of the capital stock takes the form:

$$k_{t+1} = G(k_t). \quad (\text{A.5})$$

A sufficient condition for a locally dynamically stable steady state is that $|G'(k)| < 1$ when evaluated at the steady state value of k .³² Using (22) and (23),

$$\hat{k}_{t+1} = \hat{w}_t + \hat{h}_t + \Delta \hat{\tau}_t. \quad (\text{A.6})$$

³²For a discussion of stability in the overlapping generations context, see Azariadis (1993).

where $\hat{x}$ indicates $\dot{x}/x$. Substituting by using (25), (27), (29) and (30), letting $\hat{\eta} = 0$, and evaluating at the steady state,

$$G'(k) = \alpha(1 - \Delta\varepsilon_{\tau})M_Y \quad (\text{A.7})$$

where M_Y is defined in the text and is positive because we assume a stable political equilibrium. Using (A.7), the definition of M_Y , and rearranging, stability implies

$$(1 - \alpha)(1 - \varepsilon_{hg}(1 + \varepsilon_{\tau})) + \alpha\Delta\varepsilon_{\tau} > 0. \quad (\text{A.8})$$

Therefore, if the economy exhibits intertemporal stability, the expression defined as M_K in the text is positive.

Intertemporal Stability with Fixed Government Spending

With g fixed, using (23)

$$\hat{k}_{t+1} = \hat{w}_t + \Delta\hat{\tau}_t.$$

Using (32) and the fact that wages grow at the same rate as income,

$$\hat{k}_{t+1} = \alpha\hat{k}_t - \Delta\alpha\hat{k}_t = \alpha(1 - \Delta)\hat{k}_t.$$

Stability requires $G'(k_t) < 1$ when evaluated at the steady state. Consequently,

stability requires

$$\alpha(1 - \Delta) < 1.$$

This permits us to sign the denominator of (33) when the economy exhibits intertemporal stability.

**Appendix Table II-1. Comparative Steady-State Analysis of
Effects of Demographic Transition: Constant
Relative Risk Aversion Utility
(percentage change in steady state value)**

ψ		Exogenous Fiscal Policy	Endogenous Fiscal Policy
0.32	y (output per worker)	10.7	-5.6
	k (capital per worker)	36.0	28.8
	h (human capital per worker)	0.0	-18.3
	τ (tax rate)	-10.0	-73.1
	g (government spending per worker)	0.0	-74.4
	k/h (capital per unit of h)	36.0	55.3
0.35	y (output per worker)	10.9	-0.3
	k (capital per worker)	36.8	31.6
	h (human capital per worker)	0.0	-13.0
	τ (tax rate)	-9.6	-47.8
	g (government spending per worker)	0.0	-48.3
	k/h (capital per unit of h)	36.8	51.4
0.40	y (output per worker)	11.3	4.8
	k (capital per worker)	38.2	35.8
	h (human capital per worker)	0.0	-7.8
	τ (tax rate)	-10.0	-27.9
	g (government spending per worker)	0.0	-24.2
	k/h (capital per unit of h)	38.2	47.2
0.50	y (output per worker)	12.2	12.6
	k (capital per worker)	41.6	41.8
	h (human capital per worker)	0.0	0.5
	τ (tax rate)	-11.0	-10.3
	g (government spending per worker)	0.0	1.1
	k/h (capital per unit of h)	41.6	41.1

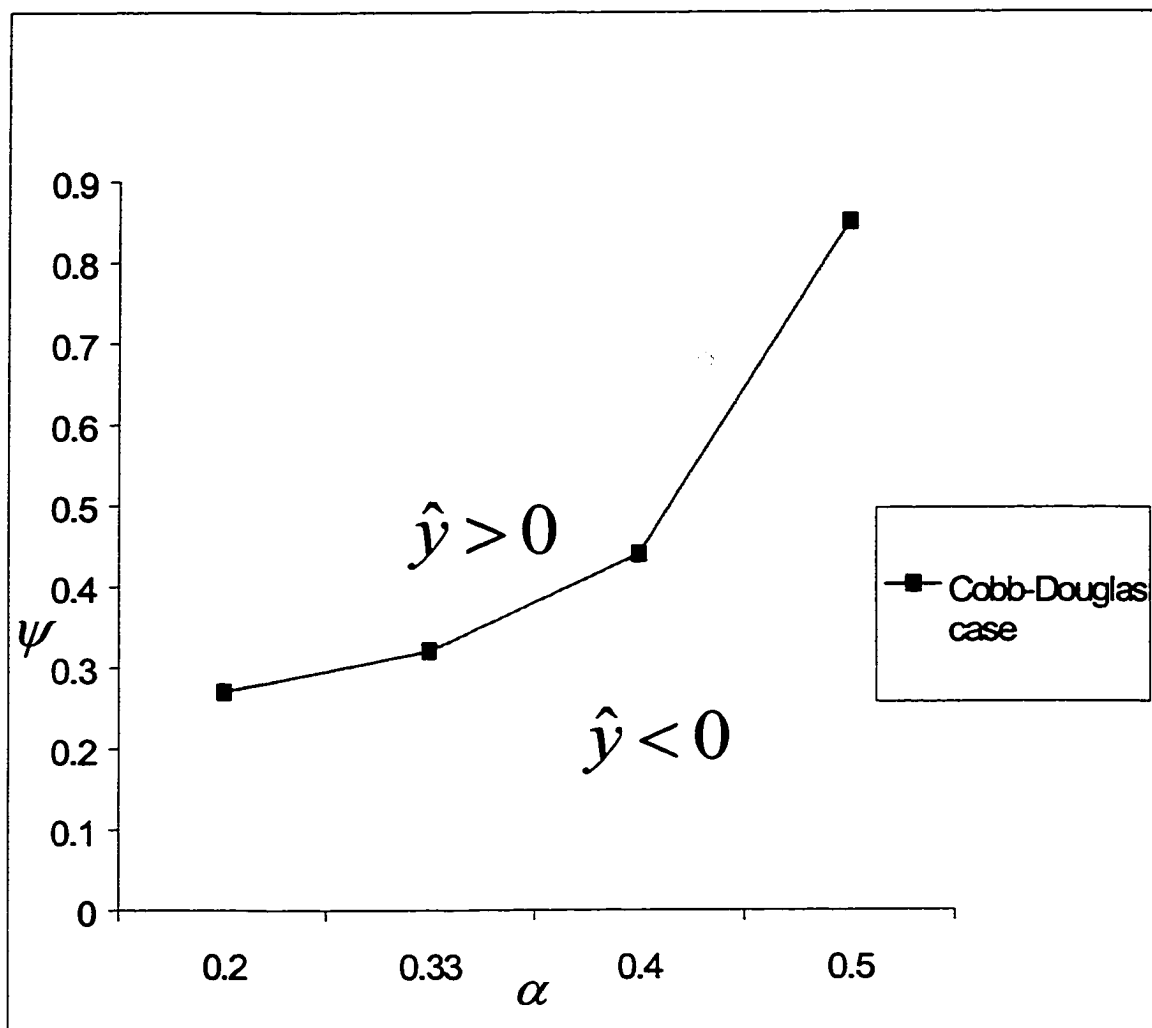
*See text for a description of simulation methods used.

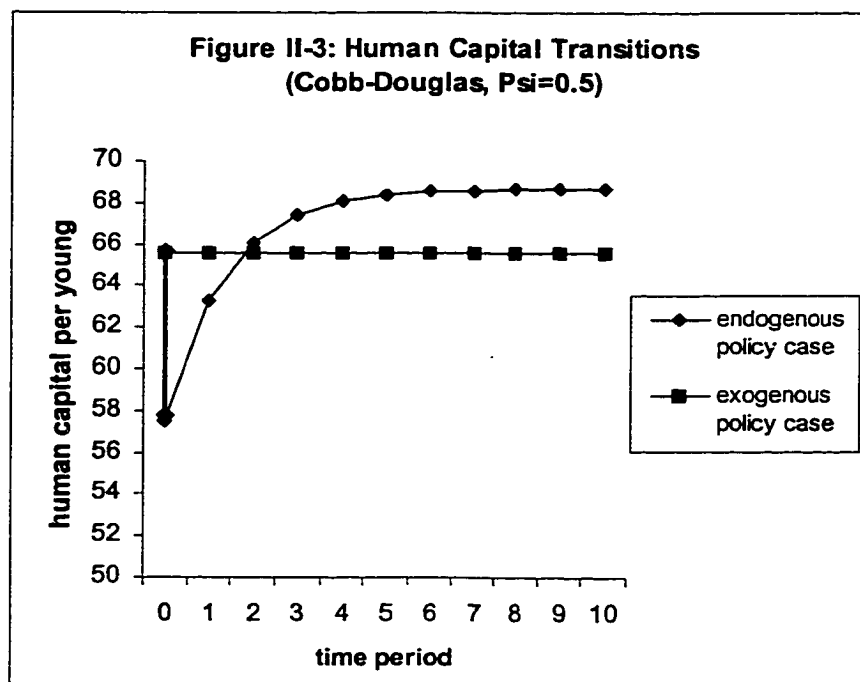
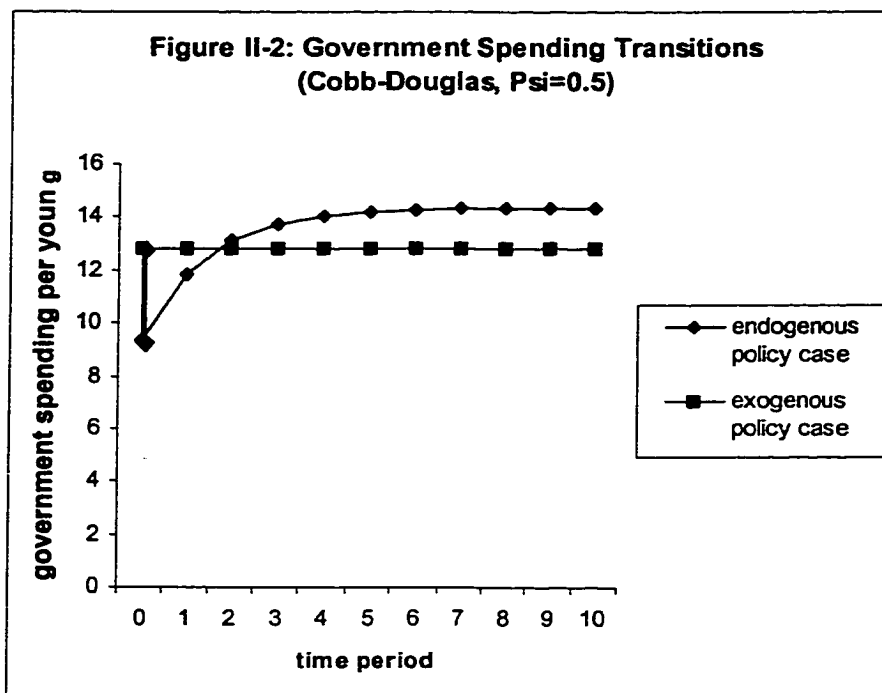
**Table II-1. Comparative Steady-State Analysis of Effects
of Demographic Transition
(percentage change in steady state value)**

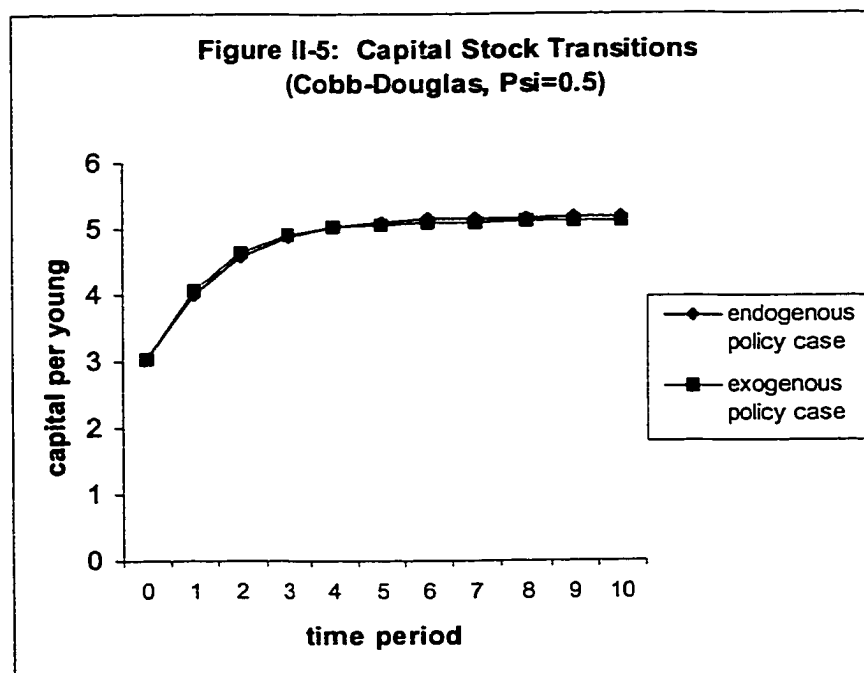
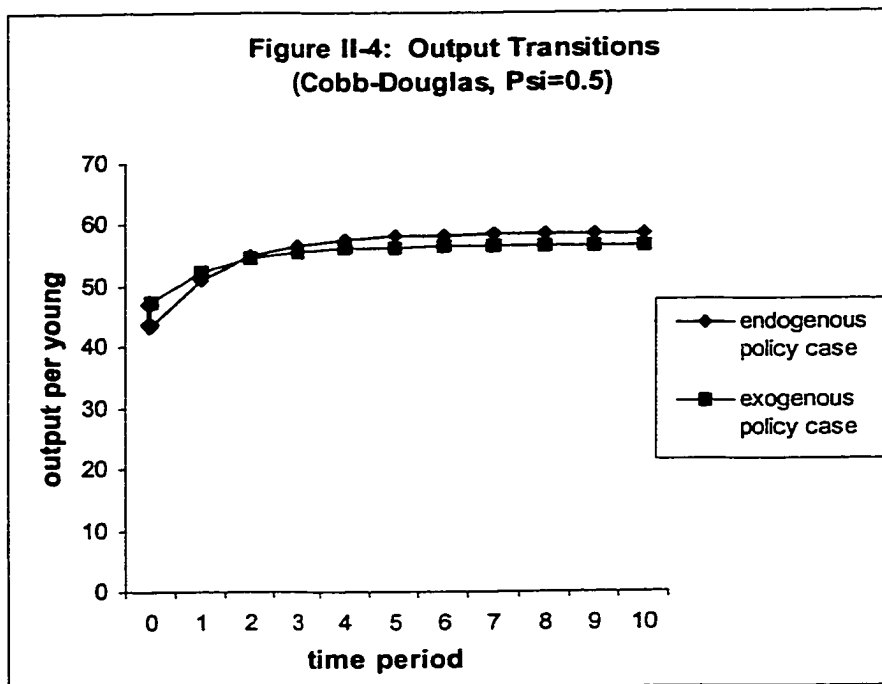
ψ		Exogenous Fiscal Policy	Endogenous Fiscal Policy
0.32	y (output per worker)	16.7	-3.8
	k (capital per worker)	59.7	44.4
	h (human capital per worker)	0.0	-21.3
	τ (tax rate)	-14.0	-90.4
	g (government spending per worker)	0.0	-91.0
	k/h (capital per unit of h)	59.7	83.3
0.35	y (output per worker)	17.0	5.3
	k (capital per worker)	61.1	54.0
	h (human capital per worker)	0.0	-12.7
	τ (tax rate)	-14.1	-52.8
	g (government spending per worker)	0.0	-50.7
	k/h (capital per unit of h)	61.1	76.4
0.40	y (output per worker)	17.6	12.4
	k (capital per worker)	63.6	60.9
	h (human capital per worker)	0.0	-5.9
	τ (tax rate)	-14.9	-28.7
	g (government spending per worker)	0.0	-19.6
	k/h (capital per unit of h)	63.6	71.0
0.50	y (output per worker)	19.0	23.2
	k (capital per worker)	69.4	71.4
	h (human capital per worker)	0.0	4.7
	τ (tax rate)	-16.2	-9.6
	g (government spending per worker)	0.0	11.6
	k/h (capital per unit of h)	69.4	63.7

*See text for a description of simulation methods used.

FIGURE II-1: Values of ψ and α Consistent with Higher and Lower Steady-State Income







References

- Azariadis, C. 1993. *Intertemporal Macroeconomics*. Cambridge, MA: Blackwell Publishers, pp. 193-204.
- Black, D. 1948. "On the Rationale of Group Decision-Making," *Journal of Political Economy*, 56: 23-34.
- Bohn, H. 1999. "Should the Social Security Trust Fund Hold Equities? An Intergenerational Welfare Analysis," *Review of Economic Dynamics*, 2(3): 666-697.
- Bohn, H. 1998. "Will Social Security and Medicare Remain Viable as the U.S. Population is Aging? Working Papers in Economics No. 98/05. Santa Barbara: University of California.
- Boldrin, M. and A. Rustichini. 2000. "Political Equilibria with Social Security," *Review of Economic Dynamics*, 3(1): 41-78.
- Börsch-Supan, A. 1996. "The Impact of Population Ageing on Savings, Investment, and Growth in the OECD Area." In *Future Global Capital Shortages: Real Threats or Pure Fiction?* Paris: Organisation for Economic Co-operation and Development, pp. 103-141.
- Börsch-Supan, A. 1995. "Regional Development, Capital Flows, and Trade Policies in an Ageing Europe." In B. Gahlen, H. Hesse, and H.J. Ramser (eds.), *Neue Entwicklungen in der Regionalökonomik*. Tübingen: J.C.B. Mohr (Paul Siebeck).
- Börsch-Supan, A. 1992. "Population Aging, Social Security Design, and Early Retirement," *Journal of Institutional and Theoretical Economics*, 148: 533-557.
- Bovenberg, A. and C. vanEwijk. 1997. "Progressive Taxes, Equity, and Human Capital Accumulation in an Endogenous Growth Model with Overlapping Generations," *Journal of Public Economics*, 64: 153-179.
- Brueckner, J.K. 1999. "Fiscal Federalism and Capital Accumulation," *Journal of Public Economic Theory*, 1: 205-224.
- Cooley, T.F. and J. Soares. 1999a. "Privatizing Social Security," *Review of Economic Dynamics*, 2(3): 731-755.

- Cooley, T.F. and J. Soares. 1999b. "A Positive Theory of Social Security Based on Reputation," *Journal of Political Economy*, 107(1): 135-160.
- Coronado, J.L., D. Fullerton, and T. Glass. 2000. "The Progressivity of Social Security," NBER Working Paper No. 7250. Cambridge, MA: National Bureau of Economic Research.
- Cutler, D.M., J.M. Poterba, L.M. Sheiner, and L.H. Summers. 1990. "An Aging Society: Opportunity or Challenge?" *Brookings Papers on Economic Activity*, 1: 1-56.
- Diamond, P. 1965. "National Debt in a Neoclassical Growth Model," *American Economic Review*, 55:1126-1150.
- Epple, D. and R.E. Romano. 1996a. "Public Provision of Private Goods," *Journal of Political Economy*, 104(1): 57-84.
- Epple, D. and R.E. Romano. 1996b. "Ends Against the Middle: Determining Public Service Provision When There Are Private Alternatives," *Journal of Public Economics*, 62: 297-325.
- Fernandez, R. and R. Rogerson. 1999. "Education Finance Reform and Investment in Human Capital: Lessons from California," *Journal of Public Economics*, 74(3): 327-350.
- Fernandez, R. and R. Rogerson. 1997. "Education Finance Reform: A Dynamic Perspective," *Journal of Policy Analysis and Management*, 16(1): 67-84.
- Glomm, G. and B. Ravikumar. 1992. "Public versus Private Investment in Human Capital: Endogenous Growth and Income Inequality," *Journal of Political Economy*, 100: 818-834.
- Glomm, G. and B. Ravikumar. 1995. "Endogenous Public Policy and Multiple Equilibria," *European Journal of Public Economy*, 11: 653-662.
- Holtz-Eakin, D. 1993. "Demographics, Political Power, and Economic Growth." In B.L. Wolfe (ed.), *On the Role of Budgetary Policy During Economic Transitions*, Proceedings of the 48th Congress of the International Institute of Public Finance/Institut International de Finances Publiques, Supplement to *Public Finance/Finances Publiques* 48:340-365.
- Kaganovich, M. and I. Zilcha. 1999. "Education, Social Security and Growth," *Journal of Public Economics*, 71: 289-309.

- Laitner, J. 2000a. "Simulating the Effect on Inequality and Wealth Accumulation of Eliminating the Federal Gift and Estate Tax," mimeo. Ann Arbor, MI: University of Michigan.
- Laitner, J. 2000b. "Earnings within Education Groups and Overall Productivity Growth," *Journal of Political Economy*, 108(4): 807-832.
- Mankiw, N.G., D. Romer, and D.N. Weil. 1992. "A Contribution to the Empirics of Economic Growth," *The Quarterly Journal of Economics*, 107: 407-437.
- Meijdam, L. and H.A.A. Verbon. 1996. "Aging and Political Decision Making on Public Pensions," *Journal of Population Economics*, 9: 141-158.
- Nechyba, T.J. 2000. "Mobility, Targeting, and Private-School Vouchers," *American Economic Review*, 90(1): 130-146.
- Persson, T. and G. Tabellini (eds.). 1994. "Growth, Distribution, and Politics." In *Monetary and Fiscal Policy, Volume 2: Politics*. Cambridge, MA: MIT Press, pp. 243-262.
- Poterba, J.M. 1997. "Demographic Structure and the Political Economy of Public Education," *Journal of Policy Analysis and Management*, 16: 48-66.
- Romer, T. and H. Rosenthal. 1983. "Voting and Spending: Some Empirical Relationships in the Political Economy of Local Public Finance." In G. Zodrow (ed.), *Local Provision of Public Services: The Tiebout Model After Twenty-Five Years*. New York: Academic Press, pp. 165-183.
- Wright, R. 1996. "Taxes, Redistribution, and Growth," *Journal of Public Economics*, 62: 327-338.

Essay III

Trade Liberalization and Tax Exporting Incentives

The art of taxation consists of plucking the goose as to obtain the largest possible amount of feathers with the least possible amount of hissing.

Attributed to Jean Baptiste Colbert

1. Introduction

Beginning in the 1980s, closed economies of the developing world began to open their borders to trade and foreign investment. Concurrently, the developed countries reduced even further their already lower barriers to trade. While worldwide trade liberalization diminished the role of international trade taxes,¹ domestic taxes increased in importance as a major source of tax revenue. Tax revenue behavior and international comparisons in terms of the level and composition of tax revenues have been widely documented in the literature.² At the state and local government level, there is an extensive literature from the United States and other industrialized countries on tax exporting, which is defined as “the process by which a tax levied by one jurisdiction is shifted (“exported”) to a taxpayer of another jurisdiction” (Phares 1999). However, incentives for tax exporting have not yet been addressed empirically at the international level. In this paper, I examine whether there has been a significant

¹Taxes on international trade include customs and other import duties, taxes on exports, and taxes on the profits of export or import monopolies (see IMF’s Government Finance Statistics 1999).

²See Tanzi (1991), Tanzi (1992), Chiancone and Messere (1989), Zee (1996), Messere (1999), and Tanzi and Zee (2000).

move towards those taxes that are potentially exportable. The analysis uses panel data on 54 countries over the period 1980 to 1996.

The starting point of studies in interstate tax exporting literature is the idea that it may be advantageous to export taxes to other jurisdictions. Pollock (1990) argues that, “desirability is supported by the relatively heavy taxation of tourist activities in most states.” Tax exporting has been extensively exploited by states, under constitutional constraints.³ From a jurisdiction’s perspective, it is a politically attractive policy tool since it enables residents of a particular jurisdiction to benefit from public services at a lower cost. It can also be politically justifiable on the grounds that other jurisdictions may have engaged in tax exporting as well. These are the main reasons why we see tax exporting used as a criterion in the analyses of various taxes.⁴ However, this does not mean that tax exporting is without its limits. For one thing, it has been questioned as a tax policy from a national perspective on ethical grounds (Oakland 1992; Zodrow 1999). Another limiting factor is interstate competitiveness. As Pollock (1990) notes, “if the state is not careful it could end up exporting jobs and economic development rather than its taxes.”

Arguments about the desirability of tax exporting are equally valid at the national and global level as well. On export taxes, Tanzi (1991) argues that following a “cynical law of taxation,” governments tend to ensue the “path of least resistance and will levy those taxes, which politically as well as administratively are easiest to

³See Brown (1992) and Schoettte (1992) for a detailed discussion of these constraints and specific court cases regarding the commerce clause challenges to state taxes.

⁴For example, Zodrow (1999) takes tax exporting as one of the main criteria to evaluate alternative tax systems. He sees exportability as a desirable feature of a state tax system.

impose and collect.”⁵ In an international setting, tax exporting can be defined as the shifting of tax burdens from the residents of one country to those of another.

International tax exporting, in its most trivial form, may result from exporting taxes directly to foreign tourists through their purchases of goods and services in a country. Indirectly, it may result from changes in the terms of trade of the country and from changes in the net return paid to foreign-owned factors of production.

To my knowledge, Damus, Hobson, and Thirsk (1991) provide the only study that addresses explicitly tax exporting in an international setting. In their general equilibrium simulation model, they distinguish between a tax exporting effect and an efficiency effect of welfare changes for a corporate tax reform in Canada. In their model, tax exporting can potentially arise from a change in the terms of trade or a change in the net return to foreign-owned capital.⁶ They conclude that the welfare effect due to potential tax exporting is a significant factor in total welfare changes.

This paper does not address long run incidence of taxes, as done by open economy Harberger models. Instead, it addresses empirically tax exporting incentives and changes in tax revenue structures at the international level. The paper is structured as follows. In the next section, I review changes in tax revenue structures. A special emphasis is placed on the link between taxes that are potentially exportable and exogenous policy changes that occurred in 1980s. This is followed by a theoretical model of optimal commodity taxation. The model and econometric considerations that guide my empirical work are explained in section 4. Section 5

⁵Tanzi (1991: 227)

presents the empirical results and provides some interpretations. The final section provides a summary and concluding remarks.

2. Changing Structure of Taxes

There has been widespread international trade and investment liberalization by developing countries throughout 1980s and 1990s. Over the same period, already low trade barriers in developed countries have been lowered yet further. This has reached a point where taxes on international trade in some developed countries have become virtually nonexistent.

There are two major events that led to significantly lower use of international trade taxes. The first took the form of GATT negotiations formally commenced by the Tokyo declaration in 1973 and completed in 1979. The Tokyo Round, also called the multilateral trade negotiations (MTN), differed from previous GATT rounds in its primary focus on reducing and regulating nontariff barriers. Ninety-nine participating countries agreed to a substantial further reduction in tariff rates by 1986, which marks the end year of the period in which the original tariff reductions were phased in.⁷

Another important aspect of the Tokyo Round was that developing countries took part in the tariff reductions for the first time. The second major event is the Uruguay Round of trade talks, which comprised 125 participating countries. The Uruguay Round consisted of comprehensive GATT negotiations commenced by the Punta del

⁷Damus, Hobson, and Thirsk (1991) consider two cases. In one, foreign capital responds to gross (of tax) rate of return, and in the other case, it responds to net (of tax) rate of return.

Este agreement of September 1986. With the formal signing in April 1994, countries reached substantial new agreements on general tariff reduction.⁸

A key feature of these events is that trade liberalization gained momentum for non-OECD countries after the mid-1980s. On the other hand, there was less of an effort within the OECD, as international trade taxes were already at considerably lower levels. Table III-1 shows the tariff rates for the OECD and non-OECD countries. While there has been a steady decline in OECD countries from 1975 onwards, the tariff rates in non-OECD countries shows a steady decline only after 1985. For this reason, it is instructive to compare the differences in the experiences of these two groups.

These events coincide with significant changes in the tax structures of countries. To demonstrate this, I employ data from two main sources: World Development Indicators 2000 (World Bank), and Government Finance Statistics Yearbooks (IMF) 1990, 1995, and 1999. I focus on the years 1980-1996, due to data availability. The pre-1980 data is not available for many countries and for many data series. There are 54 countries in the sample of which, 18 are in Europe, 2 are in North America, 8 are in Middle East and North Africa, 3 are in South Asia, 7 are in Sub-Saharan Africa, 7 are in Latin America and 9 are in East Asia and Pacific Region.

⁷The average decrease in all duties for the Tokyo Round was 29.6 percent (Yarbrough and Yarbrough 2000: 320).

⁸The average decrease in all duties for the Uruguay Round was 38 percent (Yarbrough and Yarbrough 2000: 320).

There are 22 high-income OECD, 4 high-income non-OECD, 11 upper middle-income, 9 lower middle-income, and 8 low-income countries.⁹

Table III-2 shows the changes in the shares of major tax categories in total tax revenues for 54 countries between 1980-82 and 1994-96. The figures are presented in three-year averages for four different periods.¹⁰ Consider first the differences across countries. Low and middle-income countries rely more on domestic taxes on goods and services¹¹ and on international trade taxes compared to high-income countries. High-income countries, on the other hand, rely more on taxes on income, profits and capital gains (hereafter “income taxes”) compared to lower-middle and upper-middle-income countries. The share of income taxes for low-income countries is as high as the one for high-income countries.

Because low income countries rely so little on property taxes and other taxes, such as social security contributions, the average shares of income taxes, domestic taxes on goods and services, and international trade taxes for low-income countries are higher than the average shares of these taxes for the entire sample. Now, turn to changes in tax shares over time. One apparent change is an overall movement away from international trade taxes toward domestic taxes on goods and services, for lower-middle, upper-middle, and high-income countries. This is also true for all countries taken together, despite a modest increase in international trade taxes for low-income

⁹See Appendix Table III-1 for a list of sample countries classified into income groups.

¹⁰Zee (1996) provides cross-country comparisons of tax shares for 24 OECD and 56 non-OECD countries for the period 1975-89. The tax shares presented in Table III-2 verifies some of the stylized facts presented in Zee (1996).

¹¹Domestic taxes on goods and services include general sales, turnover, or value-added taxes and excise taxes (Government Finance Statistics 1999).

countries. However, there is no common trend in income taxes. While the share of income taxes declined in low-income and high-income countries, it increased slightly in lower-middle and upper-middle income countries. The income tax share declined slightly when all countries in the sample are taken together. Finally, the property tax share remained more or less constant for the sample countries over the entire period, while the share of other taxes¹² exhibited an overall increasing trend.

Reduced reliance on international trade taxes arose from trade negotiations in 1980s. In this light, the aforementioned movement away from international trade taxes toward domestic taxes on goods and services is particularly important due to the exportability of the latter category of taxes. The main reason for the exportability of domestic taxes on goods and services is that, in a highly aggregated level, this category of taxes includes taxes on all those goods and services that cross borders. This makes domestic taxes on goods and services a good substitute for international trade taxes.¹³

3. Theoretical Model

To provide a structure for the empirical analysis, I employ a representative agent model of tax policy determination. The key assumption is that “a benevolent government adopts the fiscal system that maximizes the welfare of a representative or average citizen” (Hettich and Winer 1999: 23). In the literature, there are other more

¹²Other taxes include social security contributions, taxes on payroll or work force and other unclassified taxes. The increasing trend in other taxes may be due to a large increase in social security contributions and payroll taxes in the sample period.

complex political economy frameworks with collective choice processes, such as probabilistic voting, median voter, cooperative game theory, or structure-induced equilibrium models.¹⁴ However, my objective here is to provide a sketch of the tax exporting behavior of governments. Conveniently, in the representative agent model the objective function is simply the utility function of a representative person. In this economy, the consumer derives utility from three types of goods; a numeraire untaxed good (X_1), a taxed non-tradable good (X_2), and a taxed tradable good (X_3). The consumer also derives utility from government spending (G) which she takes it as set by the government. The consumer's utility maximization leads to the indirect utility function of the form

$$V(q_1, q_2, q_3, I, G) \quad (1)$$

where q_1, q_2, q_3 are consumer prices of X_1, X_2, X_3 , respectively, and I is personal income of the consumer.

On the production side, I assume that the profit-maximizing supplies must satisfy the aggregate production frontier

$$F[S_1(p_1), S_2(p_2), S_3(p_3)] = 0 \quad (2)$$

where S_1, S_2 , and S_3 are the market supplies and p_1, p_2 , and p_3 are producer prices of goods 1, 2, and 3, respectively. I require the following market clearance conditions and pricing identities:

¹³However, in a long run open economy Harberger setting, corporate income tax may also be exported to nonresidents (see Gravelle and Smetters 2001).

¹⁴See Hettich and Winer (1999) for a detailed discussion of these alternative theoretical frameworks.

$$X_2(q_2) = S_2(p_2) \quad (3)$$

$$X_3(q_3) + E_3(q_3) = S_3(p_3) \quad (4)$$

$$p_1 \equiv q_1 \equiv 1 \quad (5)$$

$$p_2 = q_2(1 - \tau_2) \quad (6)$$

$$p_3 = q_3(1 - \tau_3) \quad (7)$$

Here, $E_3(q_3)$ is the net exports of good 3, and τ_2 and τ_3 are *ad-valorem* tax rates on goods 2 and 3 respectively. Finally, the government budget constraint can be written as:

$$\tau_2 q_2 S_2 + \tau_3 q_3 S_3 = G \quad (8)$$

The benevolent government's problem is to choose $p_2, p_3, q_2, q_3, \tau_2$, and τ_3 by maximizing representative consumer's indirect utility in (1) subject to the constraints given by (2) to (8) above. Once the tax rates and prices are determined, the optimal level of government spending can be derived from (8). The first order conditions from this optimization problem lead to the following expression:

$$\frac{\tau_3}{\tau_2} = \frac{q_2 \left[\mu \frac{S_3}{S_3'} + \phi \frac{\partial F}{\partial S_3} - \frac{q_3 \left(V_I + \mu \frac{S_3}{X_3} \right)}{\epsilon_{x_3 q_3} + \epsilon_{E_3 q_3} \frac{E_3}{X_3}} \right]}{q_3 \left[\mu \frac{S_2}{S_2'} + \phi \frac{\partial F}{\partial S_2} - \frac{q_2 (V_I + \mu)}{\epsilon_{x_2 q_2}} \right]} \quad (9)$$

Although superficially complex, (9) reflects the basic incentives to export taxes. To see this, note that ϕ is the resource constraint multiplier, V_I is the marginal utility of a

dollar of income, and μ is the marginal utility of a dollar of government spending.

While $\epsilon_{x_2q_2}$, and $\epsilon_{x_3q_3}$ are price elasticities of demand for goods 2 and 3, $\epsilon_{E_3q_3}$ is the demand elasticity of exports for good 3. To gain some intuition regarding the implications of (9) for the observed tax structure, assume that $\epsilon_{E_3q_3} = 0$, and that market conditions facing goods 2 and 3 are identical in every aspect except for the fact that good 3 is exported. In these circumstances, (9) simplifies to

$$\frac{\tau_3}{\tau_2} = \frac{q_2 \left[\mu \frac{S_3}{S_3'} + \phi \frac{\partial F}{\partial S_3} - \frac{q_3 \left(V_I + \mu \frac{S_3}{X_3} \right)}{\epsilon_{x_3q_3}} \right]}{q_3 \left[\mu \frac{S_2}{S_2'} + \phi \frac{\partial F}{\partial S_2} - \frac{q_2 (V_I + \mu)}{\epsilon_{x_2q_2}} \right]}. \text{ Assuming that } E_3 > 0, \text{ and}$$

$\epsilon_{x_2q_2} = \epsilon_{x_3q_3} < 0$, it is easy to see that $\tau_3 > \tau_2$. That is, the good that is exported will be taxed more heavily in the domestic market, *ceteris paribus*. Similarly, if we instead let $\epsilon_{E_3q_3} \rightarrow -\infty$, under the same market assumptions, we find that (9) becomes

$$\frac{\tau_3}{\tau_2} = \frac{q_2 \left[\mu \frac{S_3}{S_3'} + \phi \frac{\partial F}{\partial S_3} \right]}{q_3 \left[\mu \frac{S_2}{S_2'} + \phi \frac{\partial F}{\partial S_2} - \frac{q_2 (V_I + \mu)}{\epsilon_{x_2q_2}} \right]}, \text{ and } \tau_2 > \tau_3. \text{ Notice that tax exporting will be}$$

maximized under the zero demand elasticity of exports for good 3, and minimized under the perfect elasticity case. Thus, I have shown that the optimal tax rate on the

good that is exported will be higher than the one on the non-tradable good as long as the demand for the exports of that tradable good is inelastic.¹⁵

4. Empirical Methodology

The dependent variable in my empirical model is the share of domestic taxes on goods and services in total tax revenues.¹⁶ This variable is designed to represent potentially exportable taxes. Although, there is a lack of unanimity regarding the notion of “potentially exportable” taxes, theoretical framework provides a guide. In theory section, I have shown that under identical market conditions, *ad valorem* tax rate on the good that is tradable is greater than the one on the nontradable good. At an aggregate level, domestic taxes on goods and services include taxes on those goods and services that cross borders. For this reason, from a set of alternative tax categories, I take domestic taxes on goods and services as potentially exportable taxes.¹⁷ However, I conduct a robustness check on my results by providing an alternative classification of exportable taxes.

The explanatory variables consist of variables that capture the tax exporting potential and other control variables. I developed the tax exporting variables in

¹⁵This is similar to the optimal tariff argument, which says that a country that is not small relative world markets can improve its terms of trade and domestic welfare by imposing a positive tariff. Here it is adopted in the form of optimal commodity tax on one tradable good.

¹⁶According to the revised manual on Government Finance Statistics, “receipts from adjustments made in connection with these taxes when goods cross a border are included. Conversely, refunds of these taxes when goods are exported are treated as negative taxes within this category.”

¹⁷This choice draws parallels with the interstate tax exporting literature. See Mclure (1967), Phares (1980), Gade and Adkins (1990), and Pollock (1991).

parallel to those used in the interstate tax exporting literature (see McLure 1967; Phares 1980; Gade and Adkins 1990).

The first and the key variable is an openness index defined as the ratio of the sum of merchandise exports and imports to the gross domestic product. Clearly, a prerequisite for a country to be able to export its taxes is to be open to the global economy, and increased openness may increase tax exporting.

Another key tax exporting variable is the share of international tourism receipts in total exports. I expect countries that attract considerable number of tourists to rely more on general sales or excise taxes, as taxes on international tourism expenditures are easy to export.

In line with the argument in section 2, I include interaction variables that capture the effect of exogenous decreases in international trade taxes through the Tokyo and Uruguay rounds. Interactions consist of three variables: a dummy variable that is set to 1 for the period after 1986, which identifies the exogenous change in the trade regimes through the Tokyo and Uruguay rounds; a dummy variable for non-OECD countries, which is used to identify the “experiment” group that experienced a rise in openness; and as explained before, an openness index which is a prerequisite for capturing incentives to export taxes. The interaction variables created with different combinations of these three variables will give us the complete effect of exogenous decreases in international trade taxes in relatively open non-OECD countries after mid-1980s. That is, the variable of interest is the interaction of all three variables above. This triple interaction gives the combined effect and is expected to

capture the positive relationship between the existence of favorable conditions for tax exportability and the share of domestic taxes on goods and services.

To demonstrate the mechanics of the triple interaction mentioned above, I conduct a preliminary analysis of the data in the spirit of a difference-in-difference approach. In Table III-3, I first put OECD and non-OECD countries into two groups based on their degree of openness. Countries with an openness level smaller than the median openness level of 30 percent for the entire sample are put into the “Low Openness” group. Whereas countries with openness level greater than 30 percent are put into the “High Openness” group. The numbers in the column “Pre-1986” indicate the average shares of domestic taxes on goods and services for the period 1980 to 1986. Similarly, the numbers in the column “Post-1986” indicate the average shares of domestic taxes on goods and services for the period 1987-1996. In line with the expected positive effect of the triple interaction variable mentioned above, I expect to see an increase in the share of domestic taxes on goods and services in highly open non-OECD countries between the two periods, relative to OECD countries and countries with low openness. In Table III-3, the share of these potentially exportable taxes in the highly open non-OECD countries increased by about 1.6 percent higher than the increase in the highly open OECD countries. The same is not true for the non-OECD countries in the “Low Openness” group. While the share of potentially exportable domestic taxes increased by 6.4 percent in OECD countries, it increased by only 0.3 percent in non-OECD countries. Table III-3 shows that the difference-in-differences-in-differences is 7.8 percent. Therefore, the increase in the tax share in

non-OECD countries after mid-1980s, is greater in “high openness” group compared to the “low openness” group after controlling for the increases in OECD countries.

The remaining control variables include the old-age dependency ratio, government spending lagged one year, GDP per capita, and finally year dummies to capture the effect any time specific events. Old-age dependency ratio is used to control for relatively heavy reliance on certain taxes such as social security contributions due to a higher proportion of elderly population. Lagged government spending controls for the size of the public sector. The size of the public sector may affect tax composition because the marginal cost of various taxes may change at different rates when the size of the public sector changes (Hettich and Winer 1984; Gade and Adkins 1990). GDP per capita controls for the size of the economies taking into consideration the population size. This is important because the sample includes low, lower-middle, upper-middle, and high-income countries. Finally, I use year dummies to capture any time specific effects.

Empirical Specification

The difference-in-differences-in-differences calculation explained above and demonstrated in Table III-2 can be expressed as the following regression equation:

$$\begin{aligned}
 EXPTAX_{it} = & \alpha + \beta_1 \text{Non-OECD} * \text{Openness} * \text{Post-1986} \\
 & + \gamma_1 \text{Non-OECD} * \text{Openness} + \gamma_2 \text{Non-OECD} * \text{Post-1986} \\
 & + \gamma_3 \text{Openness} * \text{Post-1986} + \delta_1 \text{Openness} + \delta_2 \text{Non-OECD} \\
 & + \delta_3 \text{Post-1986} + v_{it}.
 \end{aligned}
 \tag{10}$$

Where “EXPTAX” is the share of domestic taxes on goods and services in total tax revenues, “Non-OECD” is a dummy variable for the non-OECD countries,

“Openness” is an openness index measured as the ratio of the sum of merchandise exports and imports to GDP,¹⁸ and “Post-1986” is a dummy that is set to 1 for the period after 1986. While equation (10) includes the key triple interaction variable Non-OECD*Openness*Post-1986, it fails to control for other factors that may influence the share of domestic taxes. For this, I use the following specification:

$$\begin{aligned} \ln(EXPTAX_{it}) = & \alpha + \beta_1 \text{Non-OECD} * \ln(\text{Openness}) * \text{Post-1986} \\ & + \gamma_1 \text{Non-OECD} * \ln(\text{Openness}) + \gamma_2 \text{Non-OECD} * \text{Post-1986} \\ & + \gamma_3 \ln(\text{Openness}) * \text{Post-1986} + \delta_1 \ln(\text{Openness}) \\ & + \delta_2 \text{Non-OECD} + \eta Z_{it} + f_i + \phi_t + \varepsilon_{it}. \end{aligned} \quad (11)$$

All variables except dummies are logged. f_i represents the unobservable country specific, time-invariant effects, ϕ_t represents unobservable time specific effects, and ε_{it} represents time-variant unsystematic effects and is i.i.d. Z_{it} includes all remaining control variables, international tourism receipts, old-age dependency ratio, lagged government spending, GDP per capita, and year dummies.^{19,20} The inclusion of year dummies controls for the time specific effects, ϕ_t in equation (11).

In equation (11) the coefficient of interest is β_1 which is an indicator of the response of the share of potentially exportable taxes to increased openness of non-OECD countries through the Uruguay Round, controlling for all other plausible factors. The analysis of β_1 will constitute a test of the difference-in-differences-in-

¹⁸For the computation in Table III-2, a dummy for highly open countries is used instead of the continuous version of the openness index mentioned in this section.

¹⁹The dummy variable Post-1986 is omitted because of the year dummies included in the specification.

²⁰The year 1980 is excluded to avoid the dummy variable trap.

differences procedure presented in Table III-3. Table III-4 presents descriptive statistics on the variables used in this base regression.

To examine the relationship between the share of potentially exportable taxes and lower use of international trade taxes, I conduct panel data estimation using a fixed effects model. A fixed effects model has the advantage of removing the bias from the estimation caused by a possible correlation between explanatory variables and time-invariant country specific effects (f_i). It does this by wiping out these country specific effects through first differencing or means differencing. This approach in a sense uses countries as controls for themselves. Another important characteristic of the fixed effects model is that it produces consistent estimates even when the random effects model is valid.²¹ I conduct a Hausman specification test for random effects in the next section to check the robustness of the fixed effects specification.

5. Empirical Results

In order to test tax exporting for the sample countries, I begin with a fixed-effects regression as described in the previous section. Table III-5 presents the results. The estimate for the effect of old-age dependency ratio is negative and significant.²² This can be explained by a tendency to increase taxes such as social security contributions in countries with aging populations. Here, the focus is the effect

²¹However, the fixed effects estimator is not as efficient as the random effects estimator.

²²The coefficients for year dummies are not shown in Table III-5. Although they are not significant over the sample period, the coefficient estimates turn from negative to positive after 1986. This trend seems to capture the effect of the trade rounds.

captured by the triple interaction “Non-OECD*Openness*Post-1986.” The coefficient estimate for this variable is 0.164 and statistically significant at the 1 percent level. Therefore, a non-OECD country that becomes more open in the post-1986 period will tend to increase the share of domestic taxes on goods and services in its tax revenue structure. This is an important result taking into account that these taxes are potentially exportable. Also, since many of the non-OECD countries opened their economies considerably after mid-1980s, the magnitude of this effect is quite large. For instance, the coefficient shows that a 10 percent increase in the openness of non-OECD countries in the post-1986 period will increase the average share of domestic taxes on goods and services by 1.64 percent, holding other factors constant. Using the average share of domestic taxes on goods and services of 0.319, and the average annual total tax revenues of \$78 billion for the entire panel, this translates into a \$1.3 billion average annual increase in the domestic taxes on goods and services.²³ Therefore, lower use of international trade taxes associated with increased openness seems to have had a statistically and economically significant positive effect on the domestic taxes on goods and services in non-OECD countries. In the next section, I will conduct various robustness checks for this result.

Sensitivity Analysis

First, I conduct the Hausman specification test for random effects. In a random effects model, the assumption is that individual country effects f_i in equation (10) and all other regressors are uncorrelated. However, if they are correlated then the

²³The dollar amounts are in constant 1995 U.S. dollars.

coefficient estimates of the regressors in a random effects model will be systematically different from those for a fixed effects model, and the fixed effects model is strictly a better choice. The test statistic for a Hausman specification test is 7.28. So, we do not reject the null hypothesis, which says that coefficient estimates of the two models are not systematically different from each other. Thus, random effects model can still be run. The regression results from random effects estimation are shown in Table III-6, column (2). However, we know that fixed effects regression gives us unbiased and consistent estimates of coefficients whether the null hypothesis is true or not. Besides, there may still be missing factors that may lead us to reject the null hypothesis. Therefore, I will use my fixed effects model as a base model to conduct further robustness checks.

Next, I check the sensitivity of my base regression results that are reproduced in Table III-6, column (1) by omitting some of the control variables from the regression one at a time. The results for these regressions are shown in Table III-6 columns (3)-(6). Overall, the base regression results are quite robust to the omission of these variables. Non-OECD*Openness*Post-1986 is consistently significant at 1 percent level in all cases. The coefficient estimates vary between 0.161, for the regression without the lagged government spending variable in column (5), and 0.193, for the regression without the old-age dependency ratio variable in column (4). Nonetheless, the magnitudes of estimates are quite similar to 0.164 of the base regression.

On the other hand, when I include a trade variable in column (7), the magnitude of the coefficient of Non-OECD*Openness*Post-1986, even though still significant at 1 percent level, decreases to 0.133. This variable is defined as the log of the share of country's trade (exports and imports) in total world trade, and it is used to capture the market power of countries in world trade. As countries with greater market power are better suited to export their domestic taxes, this trade variable can be seen as another variable that captures tax-exporting incentives. In line with this argument, it has a positive and significant estimate. In addition, it has a considerably high estimate of 0.661. Therefore, it is plausible that this trade share variable captures some of the effects captured by Non-OECD*Openness*Post-1986, thereby reducing the magnitude of its coefficient estimate.

I conduct another robustness check for a different definition of the dependent variable. Instead of considering only domestic taxes on goods and services as potentially exportable taxes, I also include international trade taxes. So the new dependent variable is the share of sum of domestic and international taxes in total tax revenues. The results for this specification are shown in Table III-6, column (8). One thing to notice from this regression is that the variables, international tourism receipts and Openness, both have positive coefficients, 0.049 and 0.079, respectively, and while the former is statistically significant at 1 percent significance level, the latter is not significant at standard levels. Again, Non-OECD*Openness*Post-1986 is significant at 1 percent level and has a positive coefficient. However, the magnitude of the coefficient is 0.079 which is substantially lower than 0.164 in the base

regression. This may be another indicator of the decreasing trend in the share of international trade taxes. Moreover, the control variable, GDP per capita, turns negative and significant in this regression. As income per capita grows governments may choose to put a higher weight on income taxes, thinking that people with higher incomes can tolerate greater burdens. Therefore this will increase the share of personal income, payroll and property taxes, reducing the share of domestic taxes on goods and services.

Finally, I check whether my base regression results are robust to the effects of outliers in the dataset. For this, I change the estimation technique and run both a median and a robust regression. A median regression model is a special case of the generalized quantile regression. It differs from ordinary least squares (OLS) regression by its estimation of the conditional median rather than the conditional mean of the dependent variable. Similarly, robust regression is also used to correct for outliers in the data.²⁴ However, the standard errors of the estimates are generally lower than the standard errors from a median regression.

The results for both types of models are shown in the last two columns of Table III-6. The two regressions give very similar results. International tourism receipts and Openness are both significant at 1 percent level and their estimates are both positive and higher in magnitude than the ones in column (1). Non-OECD*Openness*Post-1986 has a positive coefficient in both regressions and while it is statistically significant at 1 percent level in the robust regression, it is significant at

²⁴See Rousseeuw and Leroy (1987) for a detailed discussion on robust regression.

10 percent level in the median regression. The lower significance is due to larger standard errors in the median regression compared to the robust regression. The magnitude of the coefficient in both the median regression and the robust regression are considerably higher than the base regression result in column (1). One possibility is that outliers may be exerting a downward pressure on the coefficient estimate.

6. Conclusions

There has been widespread liberalization of international trade and investment by developing countries throughout 1980s and 1990s. In the same period, already low trade barriers in developed countries have been lowered further. This has reached a point where taxes on international trade in some developed countries became almost nonexistent. While worldwide trade liberalization diminished the role of taxes on international trade, domestic taxes increased in importance as a major source of tax revenue. This suggests that the composition of available tax instruments changed in favor of those taxes that are potentially exportable. While there is little systematic evidence of this behavior using international data, there is an extensive literature on tax exporting from state-to-state in the United States and other industrialized countries.

In this paper, I provide evidence that there has been a statistically and economically significant move from international trade taxes to domestic taxes on goods and services in non-OECD countries that have experienced significant trade

liberalization particularly since mid-1980s. This is particularly important since it may reflect the policymakers' desire to export the taxes on goods and services that cross borders. Overall, this result is robust to various econometric specifications and estimation techniques.

Table III-1. Collected Tariff Rates by World Region
(in percent of value of imports)

Region	1975	1980	1985	1990	Last Available Year^a
All countries	12.62	11.36	12.27	11.05	9.70
OECD ^b	5.81	4.19	3.51	2.88	1.69
Non-OECD	15.64	14.27	15.89	14.37	12.91

^aLast year for which data are available is 1995 for most countries and an earlier year or 1996 for some countries.

^bExcluding the Czech Republic, Hungary, Luxembourg, and Poland.

Sources: Taken from Ebrill, Stotsky, and Gropp (1999), p.14, Table 1. IMF, *Government Finance Statistics*, various issues, and *World Economic Outlook* (October 1997); and OECD, *Revenue Statistics*, various years.

Table III-2: Changes in Tax Composition (1980-96)
Shares in Total Tax Revenues^a

		1980-82	1994-96
Low Income	Taxes on Income, Profits and Capital Gains	0.39	0.36
	Domestic Taxes on Goods and Services	0.34	0.34
	Taxes on International Trade and Transactions	0.24	0.27
	Taxes on Property	0.01	0.01
	Other	0.02	0.02
Lower Middle	Taxes on Income, Profits and Capital Gains	0.25	0.27
	Domestic Taxes on Goods and Services	0.32	0.38
	Taxes on International Trade and Transactions	0.31	0.21
	Taxes on Property	0.02	0.02
	Other	0.10	0.12
Upper Middle	Taxes on Income, Profits and Capital Gains	0.28	0.28
	Domestic Taxes on Goods and Services	0.30	0.34
	Taxes on International Trade and Transactions	0.21	0.11
	Taxes on Property	0.01	0.02
	Other	0.20	0.25
High Income	Taxes on Income, Profits and Capital Gains	0.39	0.36
	Domestic Taxes on Goods and Services	0.28	0.32
	Taxes on International Trade and Transactions	0.06	0.04
	Taxes on Property	0.03	0.03
	Other	0.24	0.25
All Countries	Taxes on Income, Profits and Capital Gains	0.34	0.33
	Domestic Taxes on Goods and Services	0.30	0.33
	Taxes on International Trade and Transactions	0.16	0.12
	Taxes on Property	0.02	0.02
	Other	0.18	0.20

^aThe income classifications are from World Bank's World Development Indicators (2000). Based on 1998 GNP per capita, groups are defined as follows: Low-income: \$760 or less; Lower-middle: \$761-\$3,030; Upper-middle: \$3,031-9,360; High Income: \$9,361 or more. See appendix Table III-1 for a list of countries in each group. The tax category "other" includes social security contributions, taxes on payroll or work force and other unclassified taxes.
Source: Government Finance Statistics Yearbooks (IMF), 1990, 1995, and 1999.

Table III-3. Difference-in-Differences-in-Differences^a

Median Openness (percent)		Pre-1986	Post-1986	Difference
Low Openness	Non-OECD	0.369 (0.010)	0.372 (0.008)	0.003 (0.013)
	OECD	0.226 (0.016)	0.290 (0.023)	0.064 (0.031)
				-0.062 (0.029)
High Openness	Non-OECD	0.228 (0.019)	0.257 (0.013)	0.029 (0.022)
	OECD	0.336 (0.011)	0.349 (0.008)	0.013 (0.013)
				0.016 (0.024)
				0.078 (0.037)

^aStandard errors are shown in parentheses. The numbers in the Table are average shares of domestic taxes on goods and services in total tax revenues. These are calculated using tax data from Government Finance Statistics (IMF). Openness is defined as the ratio of the sum of merchandise exports and imports to GDP. Data on exports, imports, and GDP are from World Bank's World Development Indicators (2000).

Table III-4. Descriptive Statistics^a

Variable	Number of Observations	Mean	Standard Error	Minimum	Maximum
Share of domestic taxes on goods and services in total tax revenues	897	-1.270	0.627	-4.654	-0.452
Share of international tourism receipts in total exports	899	1.831	0.848	-0.914	3.597
Old-age dependency ratio	918	4.128	0.249	3.611	4.745
Lagged government spending	892	31.801	13.164	9.420	212.000
Openness	883	3.392	0.880	1.001	5.872
Non-OECD dummy	918	0.570	0.495	0	1
Non-OECD*Post-1986	918	0.338	0.473	0	1
Openness*Non-OECD	883	1.816	1.721	0	5.872
Openness*Post-1986	883	1.993	1.804	0	5.872
Non-OECD*Openness*Post-1986	883	1.053	1.574	0	5.872
GDP per capita	913	8.545	1.515	4.439	10.734

^aAll variables, except dummies, are logged.

Source: Author's calculations.

Table III-5. Estimation Results^a
(fixed-effects model)

Variable	Coefficient	t statistic
Share of international tourism receipts in total exports	0.029 (0.023)	1.243
Old-age dependency ratio	-0.945* (0.182)	-5.195
Lagged government spending	0.032 (0.054)	0.592
Openness	-0.113 (0.099)	-1.139
Non-OECD dummy	1.017 (0.319)	3.187
Non-OECD*Post-1986	-0.528* (0.140)	-3.768
Openness*Non-OECD	-0.286* (0.095)	-3.003
Openness*Post-1986	-0.018 (0.034)	-0.522
Non-OECD*Openness*Post-1986	0.164* (0.038)	4.250
GDP per capita	-0.045 (0.067)	-0.662

R²: 0.23; Sample size: 842

^aStandard errors are shown in parentheses. All variables, except dummies, are logged. The dependent variable is share of domestic taxes on goods and services in total tax revenues.

Table III-6. Sensitivity Results^a

Variable	Baseline Fixed Effects Model (1)	Random Effects Model (2)	Without Tourism Variable (3)	Without Dependency Ratio (4)	Without Lagged Spending (5)
Share of international tourism	0.029 (0.023)	0.032 (0.023)		0.027 (0.024)	0.003 (0.023)
receipts in total exports					
Old-age dependency ratio	-0.945* (0.182)	-0.882* (0.172)	-0.969* (0.183)		-0.872* (0.181)
Lagged government spending	0.032 (0.054)	0.032 (0.052)	0.020 (0.054)	0.012 (0.055)	
Openness	-0.113 (0.099)	-0.019 (0.089)	-0.144 (0.098)	-0.060 (0.100)	-0.110 (0.100)
Non-OECD	1.017* (0.319)	1.241* (0.297)	1.023* (0.318)	0.914* (0.324)	0.976* (0.323)
Non-OECD*Post-1986	-0.528* (0.140)	-0.523* (0.140)	-0.539* (0.141)	-0.587* (0.142)	-0.541* (0.140)
Openness*Non-OECD	-0.286* (0.095)	-0.360* (0.087)	-0.282* (0.094)	-0.296* (0.097)	-0.267* (0.097)
Openness*Post-1986	-0.018 (0.034)	-0.019 (0.034)	-0.020 (0.034)	-0.043 (0.034)	-0.025 (0.034)
Non- OECD*Openness*Post- 1986	0.164* (0.038)	0.167* (0.038)	0.164* (0.039)	0.193* (0.039)	0.161* (0.038)
GDP per capita	-0.045 (0.067)	-0.075 (0.047)	-0.023 (0.067)	0.043 (0.066)	0.042 (0.065)
R ² :	0.23	0.23	0.24	0.20	0.20
Sample size:	842	842	844	842	863

^aStandard errors are shown in parentheses. All variables, except dummies, are logged. The dependent variable is share of domestic taxes on goods and services in total tax revenues.

*Indicate 1 percent significance level.

**Indicate 5 percent significance levels.

***Indicate 10 percent significance levels.

Table III-6. Continued^a

Variable	Without GDP Per Capita (6)	With Trade as Another Explanatory Variable (7)	With Alternative Dependent Variable (8)	Median Regression (9)	Robust Regression (10)
Share of international tourism receipts in total exports	0.023 (0.024)	0.043*** (0.023)	0.049* (0.016)	0.088* (0.027)	0.048* (0.018)
Ratio of the sum of exports and imports to total world trade		0.661* (0.196)			
Old-age dependency ratio	-0.900* (0.181)	-0.771* (0.187)	-0.504* (0.123)	-0.195 (0.193)	0.065 (0.099)
Lagged government spending	0.039 (0.055)	0.058 (0.054)	-0.052 (0.037)	-0.077 (0.092)	-0.092** (0.047)
Openness	-0.161 (0.101)	-0.689* (0.176)	0.079 (0.067)	0.272* (0.098)	0.189* (0.057)
Non-OECD	0.962* (0.326)	1.013* (0.316)	0.742* (0.216)	1.637* (0.369)	1.447* (0.226)
Non-OECD*Post-1986	-0.552* (0.144)	-0.475* (0.139)	-0.296* (0.095)	-0.946*** (0.565)	-1.077* (0.289)
Openness*Non-OECD	-0.268* (0.098)	-0.272* (0.094)	-0.180* (0.064)	-0.487* (0.106)	-0.435* (0.061)
Openness*Post-1986	-0.020 (0.035)	0.004 (0.034)	-0.043*** (0.023)	-0.107 (0.143)	-0.146** (0.070)
Non- OECD*Openness*Post- 1986	0.170* (0.039)	0.133* (0.039)	0.079* (0.026)	0.268*** (0.152)	0.299* (0.021)
GDP per capita		-0.638* (0.164)	-0.183* (0.046)	-0.068** (0.032)	-0.010 (0.021)
R ² :	0.23	0.25	0.08	0.09	
Sample size:	843	840	842	842	842

^aStandard errors are shown in parentheses. All variables, except dummies, are logged. The dependent variable is share of domestic taxes on goods and services in total tax revenues except in column (8). In (8) the dependent variable is the share of the sum of domestic and international trade taxes in total tax revenues. Bootstrap standard errors are used in the median regression results in column (9). R² reported for median regression is a pseudo-R².

*Indicate 1 percent significance levels.

**Indicate 5 percent significance levels.

***Indicate 10 percent significance levels.

**Appendix Table III-1. List of Sample Countries
by Income Groups^a**

Low Income	Malaysia	Spain
Cameroon	Mexico (OECD)	Sweden
Ethiopia	Panama	Switzerland
India	Turkey (OECD)	United Kingdom
Indonesia	Uruguay	United States
Kenya		
Pakistan	High Income	
Zambia	Australia	
Zimbabwe	Austria	
	Belgium	
Lower Middle Income	Canada	
Costa Rica	Denmark	
Egypt	Finland	
Jordan	France	
Morocco	Greece	
Philippines	Iceland	
South Africa	Ireland	
Sri Lanka	Israel (non-OECD)	
Thailand	Italy	
Tunisia	Japan	
	Kuwait (non-OECD)	
Upper Middle Income	Luxemburg	
Argentina	Malta (non-OECD)	
Bahrain	Netherlands	
Botswana	New Zealand	
Brazil	Norway	
Chile	Portugal	
South Korea (OECD)	Singapore (non-OECD)	

^aThe income classifications are from World Bank's World Development Indicators (2000). According to the classification based on 1998 GNP per capita, groups are defined as follows: Low-income: \$760 or less; Lower-middle: \$761-\$3,030; Upper-middle: \$3,031-9,360; High Income: \$9,361 or more. Countries in the high-income group are also OECD members, unless indicated otherwise. With South Korea, Mexico, and Turkey there are 25 OECD member countries in the sample. Note that Mexico and South Korea became OECD members in 1994 and 1996, respectively.

References

- Brown, W.R. 1992. "Techniques of State Tax Exporting." In Thomas F. Pogue (ed.), *State Taxation of Business: Issues and Policy Options*. Connecticut: Praeger Publishers, pp. 99-116.
- Chiancone, A. and K. Messere. 1989. *Changes in Tax Revenues*. Detroit, MI: Wayne State University Press.
- Damus, S., P.A.R. Hobson, and W. R. Thirsk. 1991. "Foreign Tax Credits, the Supply of Foreign Capital, and Tax Exporting: A Numerical General Equilibrium Model of Corporate Tax Reform in Canada," *Journal of Public Economics*, 45: 29-46.
- Ebrill, L., J. Stotsky, and R. Gropp. 1999. *Revenue Implications of Trade Liberalization*, Occasional Paper 180. Washington, DC: International Monetary Fund.
- Gade, M. and L. Adkins. 1990. "Tax Exporting and State Revenue Tax Structures." *National Tax Journal*, 43: 39-42.
- Gravelle, J.G. and K. Smetters. 2001. "Who Bears the Burden of the Corporate Tax in the Open Economy?," NBER Working Paper 8280. Cambridge, MA: National Bureau of Economic Research.
- Hettich, W. and S.L. Winer. 1984. "A Positive Model of Tax Structure", *Journal of Public Economics*, 24: 67-87.
- Hettich, W. and S.L. Winer. 1999. *Democratic Choice and Taxation*. Cambridge, UK: University Press.
- International Monetary Fund. 1990, 1995, 1999. *Government Finance Statistics Yearbook*. Washington DC: IMF.
- McLure, C.E. 1967. "The Interstate Exporting of State and Local Taxes: Estimates for 1962", *National Tax Journal*, 20(1): 49-77.
- Messere, K. 1999. "Half a Century of Changes in Taxation," *Bulletin for International Fiscal Documentation*, 53(8-9): 340-65.
- Oakland, W.H. 1992. "How Should Businesses Be Taxed?" In Thomas F. Pogue (ed.), *State Taxation of Business: Issues and Policy Options*. Connecticut: Praeger Publishers, pp. 17-34.

- Phares, D. 1999. "Tax Exporting." In J.J. Cordes, R.D. Ebel, and J.G. Gravelle (eds.), *The Encyclopedia of Taxation and Tax Policy*. Washington, DC: The Urban Institute Press.
- Phares, D. 1980. *Who Pays State and Local Taxes?* Cambridge, MA: Oelgeschlager, Gunn and Hain, Publishers, Inc.
- Pollock, S.H. 1991. "Mechanisms for Exporting the State Sales Tax Burden in the Absence of Federal Deductibility," *National Tax Journal*, 44: 297-310.
- Rousseeuw, P.J. and A.M. Leroy. 1987. *Robust Regression and Outlier Detection*. New York: Wiley.
- Schoettle, F.P. 1992. "Economic Analysis and Expert Testimony in Commerce Clause Challenges." In Thomas F. Pogue (ed.), *State Taxation of Business: Issues and Policy Options*. Connecticut: Praeger Publishers, pp. 125-42.
- Tanzi, Vito. 1992. "Structural Factors and Tax Revenue in Developing Countries: A Decade of Evidence." In Ian Goldin and L. Alan Winters (eds.), *Open Economies: Structural Adjustment and Agriculture*. New York: Cambridge University Press, pp. 267-89.
- Tanzi, Vito. 1991. *Public Finance in Developing Countries*. Vermont: Edward Elgar Publishing, pp. 227-231.
- Tanzi, Vito and Howell H. Zee. 2000. "Tax Policy for Emerging Markets: Developing Countries," *National Tax Journal*, 53(2): 299-322.
- World Bank. 2000. *World Development Indicators*, Washington, D.C.: World Bank.
- Yarbrough, B.V. and R.M. Yarbrough. 2000. *The World Economy: Trade and Finance*, Fifth Edition. Orlando FL: Harcourt Brace, p.320.
- Zee, Howell H. 1996. "Empirics of Crosscountry Tax Revenue Comparisons," *World Development*, 24(10): 1659-71.
- Zodrow, George R. 1999. *State Sales and Income Taxes: An Economic Analysis*. College Station, TX: Texas A&M University Press.

Biographical Data

Name:	Mehmet Serkan Tosun
Date and Place of Birth:	May 7, 1971 Karaman, Turkey
High School:	T.E.D. Ankara College Ankara, Turkey
College:	B.A., Economics, Bogazici University Istanbul, Turkey
Graduate Work:	M.A., Economics Boston University Boston, MA