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Macroeconomic and Policy Implications of Population Aging in Brazil

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Abstract

This paper analyzes the macroeconomic implications of population aging in Brazil. Three alternative yet complementary methodologies are adopted, and depending on policy responses to the fiscal implications of aging, there are two main findings: First, saving rates could increase and not necessarily fall as a consequence of aging in Brazil—thus contradicting conventional views. Second, lifetime wealth across generations could increase—as capital deepening generates a second demographic dividend. Two policy responses to aging are emphasized: First, a structural policy response of linking mandatory retirement (or entitlement) ages to increasing life expectancy would boost labor supply and reduce the fiscal costs of aging. Second, in terms of preferable parametric policy responses, the second demographic dividend will be promoted to the highest extent by keeping taxes and debt unchanged while allowing public pensions to adjust downward. Such a policy response would keep pensions from further crowding out private saving—thus balancing capital accumulation with intergenerational income distribution. In conclusion, Brazil will not necessarily experience a fall in saving and growth, but if government policies are appropriately, adequately, and timely formulated, population aging is likely to lead to substantial capital deepening and increases in lifetime income, wealth, and welfare.

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MACROECONOMIC AND POLICY IMPLICATIONS OF POPULATION AGING IN BRAZIL*

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Keywords: Population aging; Brazil; saving; economic growth, labor supply; demographic dividend; retirement age; fiscal policy; debt.

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** Ole Hagen Jorgensen, The World Bank, Latin America and the Caribbean Region, Economic Policy Unit (LCSPE), Email: ojorgensen@worldbank.org; oj@ojconsult.dk. The views expressed in this paper are the author's alone, and not necessarily the views of the World Bank Group. A technical appendix for model derivations, data sets, and simulation models are available upon request.

1. Introduction

Population aging is an inevitable consequence of the demographic transition. Economic behavior and macroeconomic outcomes change both systematically and endogenously with aging. Therefore, aging countries are bound to experience pressure on fiscal sustainability, while saving and investment are risking falling short of what is needed to keep capital accumulation, wealth, and welfare at desirable levels.

Sufficient saving is important for an economy in order to generate a high income per capita. Population aging has two direct effects on saving: First, aging is traditionally believed to reduce aggregate saving rates because the fraction of people that are "prime" savers will decrease and the dis-saving fraction will increase as implied by the life-cycle hypothesis (LCH) by Modigliani (1966, 1970), Modigliani and Brumberg (1954a,b). This effect will lead to lower economic growth (Solow, 1956; Lee, 1994; Lee and Mason, 2007; Weil, 1997). Second, increasing life expectancy is the other important component of population aging and will lead to a higher saving rate as people anticipate a longer retirement period to be financed partly by private saving (Jorgensen and Jensen, 2010). These two effects consequently have an offsetting impact on saving — and thus on growth.

To further point out the complexity of this issue, what if age-specific saving rates do not decline in old age as posited by LCH? There may be desire to leave bequests (Kotlikoff and Summers, 1981, 1988; De Nardi, et al. (2009), or for elderly to share their pension income with cohabitating children (Barro, 1974). There are a large number of possible indirect effects of aging on saving. For example, when fewer workers must finance a growing number of elderly receiving public pensions, tax rates might create distortions that lead to lower demand for leisure and, thus, positive endogenous effects on the intensity of labor supply. Alternatively, the intensity of labor supply might fall when statutory retirement ages are often increased as a policy response to aging and people experience their lifetime leisure falling. Furthermore, the way in which the Brazilian government decides to finance the inevitably increasing costs for social security and health will also have major implications for the behavioral responses of Brazilians. So, the behavioral dynamics of saving are not only endogenous to aging but also to government financing policies.

The macroeconomic implications of population aging in Brazil are analyzed in this paper using three alternative yet complementary methodologies. First, the international and Brazil-specific *econometric evidence* on the aging-saving transmission channel is analyzed. Second, a *partial equilibrium* model is developed to exploit the rich household data on exogenous age-specific saving rates in Brazil. Third, as partial equilibrium analyses do not take into account the potentially endogenous behavioral responses to aging (Acemoglu, 2010) a *general equilibrium* model is finally presented. Simulations are performed for different scenarios of income inequality and government policies, and the implications for key macroeconomic aggregates, such as saving, wealth, and welfare, are analyzed and discussed in light of the advantages and disadvantages of the different models.

The main findings of the three complementary analyses are the following. In relation to the *econometric evidence* for Brazil, a higher saving rate is found to lead to higher income growth. This is an empirically well-established relationship for most countries. What is more controversial is the econometric finding that an increase in the old-age dependency ratio has, so far, led to an increase in the private saving rate — suggesting that aging may lead to higher growth in the future due to higher saving rates. The econometric evidence is paired with a literature review that places Brazil in international context regarding the relationship between population dynamics and saving — revealing that Brazil is not the only developing country that has experienced such unexpected dynamics (Chawla, Betcherman, and Banerji, 2007). Ultimately, there is no econometric evidence suggesting that an increasing old-age dependency ratio has led to reductions in saving and growth.

The partial equilibrium results suggest that saving rates in Brazil depend crucially on public pensions; elderly tend to save a large fraction of public pensions, effectively leading to just as high saving rates for elderly as for workers. If Brazil maintains relatively high public pensions, it is therefore likely that the saving rate will increase since the population structure will be composed by a larger fraction of high-saving workers and elderly rather than low-saving young. Even if inequality remains unchanged in the future, this shift in the population structure is likely to increase the saving rate. If inequality falls there will be even more high-savers because the non-poor are found to save more than the poor — thus promoting savings even further.

In the general equilibrium setting, three scenarios for financing the fiscal costs associated with aging will be compared: *Tax-Financing*, where taxes increase to absorb the costs; *Benefit-Financing*, where social security benefits per elderly fall to accommodate the fiscal pressure; and *Debt-Financing*, where public debt increases so the government can refrain from changing taxes or benefits. Benefit-Financing is found to be strongly preferable as a financing method since capital accumulation and wealth is increasing when the population ages. Consequently, with appropriate policies, there is scope for promoting the second demographic dividend and keeping welfare at least constant over the period 2010 to 2050.

A possible reform of the relatively generous Brazilian social security system should consider the advantages involved with indexing the age of eligibility to pension benefits (the statutory retirement age) to life expectancy. Such a policy response is analytically formulated by Jorgensen and Jensen (2010) and has informed policy debates particularly across OECD countries. A key driver of the general equilibrium results is endogenous capital accumulation — signifying the second demographic dividend.

The scope of this paper does not encompass all the transmission channels through which aging will lead to macroeconomic changes. Decisions over labor force participation, and endogenous changes in effective retirement ages, are not consider explicitly. Bloom and Canning (2008) and Bloom et al. (2009) deal with such issues in a broader context, and the institutional settings for harvesting the demographic dividend is neither incorporated (Bloom and Canning, 2003; and Bloom et al., 2007). These and other excluded issues will remain for future research on the economic implication of aging in Brazil.

Section 2 presents new econometric evidence for Brazil on the aging-saving relationship, while reviewing the literature in order to place Brazil in an international context. Section 3 builds and simulates the partial equilibrium model in order to evaluate the likely implications aging will have for household saving rates depending on scenarios for inequality. Section 4 concludes the triad of methodologies applied to analyze the macroeconomic implications of aging by constructing a general equilibrium model where both saving, wealth, and welfare can be analyzed in the overall context of the possible second demographic dividend in Brazil. Section 5 provides the final conclusion.

2. Aging, Saving, and Growth: The Empirical Evidence

Could population aging affect growth through saving in Brazil? The traditional view is that growth should be negatively associated with aging because aging would reduce saving — and lower saving would reduce growth. But is this really what aging has in store for Brazil? To address this question for Brazil, it is necessary to econometrically analyze the *aging-saving* and *saving-growth* relationships, respectively. Before focusing on the aging-saving relationship — the main focus of this paper — the saving–growth relationship needs to be firmly econometrically established in the case of Brazil. The significant and robust finding that saving is an important determinant of growth then motivates the analysis of the aging–saving relationship.

Econometric Evidence on the Saving-Growth Relationship

Rodrik (2000) argues that the accumulation of physical capital is the proximate source of economic growth, and in the context of standard growth theory saving is critical in order to maintain a high income per capita (Solow, 1956). In a country-study, such arguments warrant an econometric analysis of the evidence. Building on Brazilian data from IPEA, a vector auto-regression (VAR) analysis is performed in order to study whether gross or private saving positively (Granger) causes economic growth over time. A key reference for this interrelation between saving and growth in a panel setting is Attanasio (2000). The findings for Brazil are compared to those by Attanasio in Table 1.

Table 1. Private Saving is Found to Granger Cause Growth in Brazil

	Private saving and private investment *(VAR regressions on Brazil)*	Gross saving and gross investment *(VAR regressions on Brazil)*	Gross saving and gross investment *(Multi-country panel analysis)*
Saving on Growth	+***[+**]	+[+]	+**
Growth on Saving	+[+]	+[+]	+**
Investment on Growth	-**[-**]	-[-]	-**
Growth on Investment	+*[+*]	+*[+]	+**
Saving on Investment	+[+]	+[+]	+**
Investment on Saving	-[-]	-[-]	+**

Source: Author's estimations. Results in brackets for difference-estimations. Significance at 10, 5, and 1 percent levels are denoted by ***; **; *. The dynamic tri-variate model by Attanasio et al. (2000) was OLS-based with a sample of 38 countries over the period 1960-1994 — controlling for simultaneity and country heterogeneity. See Orazio et al. (2000) for another comparative study.

All except one relationship for Brazil in Table 1 confirm the findings by Attanasio (2000) — thus making the case even stronger that private saving causes growth.[1] The finding is robust to the measure of saving being either gross or private. Cumulative impulse response functions from the VAR model further support the positive growth-implications over time of an increase in private saving.[2] Private saving is found to positively but insignificantly affect investment; growth significantly increases investment; and if investment increases in the short term, growth may fall since output is used for long term investment rather than consumption—over the long term investment positively affects growth. These relationships for Brazil conform well to the established macroeconomic literature.

Econometric Evidence on Aging-Saving Relationship

Standard life cycle models generate a strong link between the age composition of the population and private saving. Also, cross-country econometric studies using aggregate time-series data reveal correlations between saving rates and demographic structure broadly confirming LCH predictions; countries with more elderly populations tend to have lower saving rates (Graham, 1987; Koskela and Viren, 1992; Masson et al., 1998; and Miles, 1999).

The international evidence on whether saving follow the LCH is mixed if low and middle-income countries are also considered — and highly dependent on how income is estimated. Households do not seem to run

[1] In a separate VAR model where public saving and the old-age dependency ratio are included in the equation system, the result still holds. These supplementary results are available upon request.

[2] There is one important caveat of this analysis, however. The data on public and private saving in Brazil is not as reliable as one would hope. The period 1984 to 1994 are somewhat unreliable, because the public and private saving were not available from IPEA, and this is the period where public and private saving is then seen to display a spike. The IMF is as the source for public saving within this period. On the other hand, Morandi (1998) finds a similar spike in private saving, though smaller. Oliveira et al. (1998) find a similarly smaller spike within this period.

down their stocks of wealth in retirement at the rate predicted by the LCH (Poterba, 1994; Gregory et al. 1999). Generally, therefore, the saving rate of retirees does not fall as much as LCH predicts, and Miles (1999) clarifies that a key error in traditional estimations is to count all pension receipts as income. Bosworth et al. (1991) estimate the average savings rate for retirees in the United States, correcting for the pension adjustment suggested by Miles (1999), and find that the traditional measure of the unadjusted savings rate was 14.9 percent, while the measure that was adjusted by private pensions was 1.8 percent.

A literature review — presented in Table 3 — reveals that the expected correlation between the dependency ratio and private saving may be insignificantly positive for transition countries (incl. Brazil), though it would be expected to display a negative relationship for developed countries. This is likely to be caused by the simple fact that household saving rates remain high in old age. Also, the old-age dependency ratio is likely to be insignificantly positive for Latin American and Caribbean (LAC) countries as a subgroup.

Meredith (1995) estimated that a 10 percentage point increase in the old-age dependency ratio could reduce the savings rate by around 9 percentage point, while a 0.1 percentage point drop in the young-age dependency ratio would lead to an increase in the savings ratio of about 6.1 percentage points. Also, simulations by Miles (1999), based on a model that assume the LCH, found that the private savings rate in European economies could fall from 15.9 percent (of GDP) in 1990 to around 4.5 percent by 2060.

An additional element of aging is increased life expectancy at older ages (or equivalently, lower old-age mortality). Higher life expectancy may raise the rate at which individuals save during working life — either reversing or amplifying the effect which stems from higher old-age dependency ratios, depending on the economic and country-context. Life expectancy is, indeed, found to positively impact private saving in Table 2, and this is supported for LAC countries. Roeger (2006) furthermore finds that life expectancy in the euro area is projected to increase by around five years over the next four decades, but that the positive effect on domestic savings is not likely to offset the impact of the increasing old-age dependency ratios.

Table 2. The Old-Age Dependency Ratio Increases Private Saving

Step 1 Dependent variable: Private saving rate	*Coefficient (Standard error)*
log of GDP per cap	-5.53* (3.03)
private investment rate	0.89*** (0.20)
public saving rate	-1.22*** (0.13)
growth of old dependency rate	1.40* (0.82)
real interest rate	0.02 (0.03)
Constant	52.36* (28.69)
R_2 (Phillips-Perron test)	0.87 (-16.93*)
Step 2 Dependent variable: Δ Private saving rate	
Δ log of GDP per cap	4.73 (8.50)
Δ private investment rate	0.96*** (0.20)
Δ public saving rate	-1.00*** (0.10)
Δ growth of old dependency rate	3.02* (1.52)
Δ real interest rate	0.04* (0.02)
Adjustment coefficient α	-0.42*** (0.16)
Constant	52.37* (0.35)
R_2	0.87

Source: Author's estimations. Significance at the 10, 5, and 1 percent levels are denoted by ***, **, *, respectively. Data includes 38 observations.

The discussion above reviewed the international econometric evidence on the aging-saving relationship; but what is the evidence for Brazil? Using an error-correction model to address this question, Table 2 reveals that the old age dependency ratio positively (Granger) causes private saving both in the short term with a coefficient of 3.02 and over the long term with a coefficient of 1.40. This is contrary to the international literature mainly on developed countries but not necessarily to what is observed in developing countries.

It is furthermore found that public saving crowds out private saving, which is consistent with findings in Paiva and Jahan (2003). A negative effect of the GDP growth on the private saving rate in the long run is unexpected, however. The problem with a single equation error-correction model could be a simultaneous equation bias if the causality between private saving and one of the other variables runs both ways, which could explain the negative coefficient of GDP per capita in the long run relationship. An alternative is to use Johansen approach of vector error-correction, but this is not pursued due to the small number of observations. [3]

Simple OLS estimations by Jorgensen (2010a) further reveal that the private saving rate is significantly and positively correlated with the total dependency ratio. On the other hand, in OLS estimations, the old age dependency ratio is found to be negative — which is a finding that supports the LCH but counters the error-correction approach followed above. As such, the econometric evidence is somewhat ambiguous. Also, life expectancy is found to positively contribute to private saving — and to a significant extent when pension benefits are included in the estimations. Higher inequality, as measured by the Gini-coefficient, is seen to positively affect the precautionary saving motive because it increases the private saving rate. This is also true in estimations where inflation is excluded and the Gini-coefficient is included in order to avoid double-counting the precautionary saving motive.[4]

In the future, the dependency ratio will be driven mainly by the old-age dependency ratio rather than the youth dependency ratio. Could that cast doubt about the empirical results found in this section? In the simple (and not always preferable) OLS regressions the youth dependency ratio was found to positively and significantly increase the private saving rate over the period 1970-2008; while old age dependency ratio was found to lower the private saving rate. Since the total dependency ratio was found to increase the private saving rate — and because the total dependency ratio was mainly driven by changes in the youth dependency ratio — a stronger future role of the old age dependency ratio in driving the total dependency ratio may lead to the reverse relationship between the total dependency ratio and the private saving rate.

As a result, the econometric evidence above is valuable to establish a historical relationship between population dynamics, saving, and growth, but the estimated coefficients may not necessarily be relevant for the future demographic-economic projections. In the above time series analyses, problems of endogeneity of wages, interest rates, tax rates and wealth accumulation with respect to the demographic structure tend to be handled by instrumental variables approach, if they are addressed at all.

Little attempt is made to structure models in a way that is consistent with individual maximizing behavior, but life-cycle general equilibrium models, which are founded on microeconomic optimization, have real advantages (Miles, 1999). Therefore, the aim in this paper is to dig deeper into the relationship between population dynamics and economic behavior — which will be attempted in the next two sections.

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[3] It has been attempted to also include in the error-correction model the terms of trade, M2, and the inflation rate, but they did not produce significant results.

[4] The above evidence on the saving-growth and aging-saving relationships has been purely empirical. The evidence suggests that the old-age dependency ratio is likely not to have negative effect on private saving over the time period covered (1970-2008). This might also be the case in the future, but such projections would always be subject to the Lucas-critique, i.e. that parameters used in projections might change if exogenous shocks or policy reforms suddenly appear.

Table 3. Determinants of the Private Saving Rate (in Panel Studies)

Variable category	*Specific variable*	*Expected sign*	*Empirical finding (cross country)*
Demographics	Dependency ratio	–	– (3, 6) 0 (1, 7, 9, 10) +(17 (*insignificantly positive for transition economies incl. Brazil*))
	Old age dependency ratio	–	– (1, 4, 5, 6, 12, 14 (*insignificantly positive for LAC)*) 0 (7, 9, 13)
	Youth dependency ratio	–	– (1, 4, 6, 12, 14 (*insignificantly negative for LAC*)) 0 (7, 13)
	Life expectancy	+	+ (15, 14 (*insignificantly positive for LAC*))
	Urbanization	Ambiguous	– (1, 4) + (17 (*transition economies incl. Brazil*))
Fiscal policy	Gross public saving to GDP	–	– (3, 4, 5, 8, 9, 10, 11, 17 (*transition economies incl. Brazil*))
	Government net lending	–	– (1, 6, 7)
	Public surplus	–	– (6, 13, 7) 0 (12)
	Public consumption	Ambiguous	– (6, 7)
Rate of return	Real interest rate	Ambiguous	– (1, 8) 0 (1, 3, 4, 7, 9, 10, 11, 13) + (5, 6, 7)
Uncertainty	Inflation rate	+	0 (3, 5, 7, 8, 10) + (1, 6, 9)
	Measures of political stability	+	– (12) 0 (11, 6, 4) + (1)
Income	GDP	0 or +	+ (11, 6, 4, 12, 1, 17 (*transition economies incl. Brazil*)) 0 (13, 7)
	Growth rate of GDP per capita	Ambiguous	+ (3, 6, 4, 1, 10) 0 (9, 12, 13, 7)
	GDP growth	0 or +	+ (5) 0 (6, 7)
	Labor productivity growth	0 or +	+ (8)
Competitiveness	Terms of trade	0 or +	+ (1, 6, 7, 8, 9, 12, 17 (*transition economies incl. Brazil*))
Domestic borrowing constraints	Private credit flows	–	+ (3, 4) – (1)
	Credit to GDP ratio	Ambiguous	0 (9, 10)
Foreign borrowing constraints	Current account deficit	–	– (1, 11, 4, 6)
Financial depth	Private or domestic credit stock	Ambiguous	– (13)
	Money stock to GDP	Ambiguous	+ (11, 4, 12) 0 (1)
Pension system	Pay–as–you–go transfers	0 or –	– (4, 12, 13)
	Mandatory funded pension contributions	0 or –	+ (12)
	Fully funded pension assets	Ambiguous	0/+ (13)
Distribution of income and wealth	Income concentration	Ambiguous	0 (4)

Source: Authors compilation based on the following references: The results listed under Empirical findings summarize the significance of saving regressors in the following studies, where only statistically significant findings are reported: (1) Loayza, Schmidt–Hebbel and Serven (2000); (2) Fletcher et al. (2007); (3) Edwards (1995); (4) Edwards (1996); (5) Callen and Thimann (1997); (6) Masson, Bayoumi and Samiei (1998); (7) Haque, Pesaran, and Sharma (1999); (8) De Serres and Pelgrin (2002); (9) Ozcan, Gunay, and Ertac (2003); (10) Schrooten and Stephan (2005); (11) Corbo and Schmidt–Hebbel (1991); (12) Dayal-Gulati and Thimann (1997); (13) Bailliu and Reisen (1998); (14) Doshi (1994), (15) Bloom and Canning (2008); (16) Paiva and Jahan (2003); and (17) Rodrik (1998).

3. Aging and Saving

How will the saving rate evolve when the population is aging in Brazil? That is the main question of this paper. It is well known that population aging is likely to reduce the saving rate because there will be a larger share of elderly who may not have an incentive to save very much. What if, however, the LCH is not supported in Brazil when the elderly also save? In that case, a larger share of elderly will not reduce the saving rate; in fact, population aging may then increase the saving rate, and since the share of children in expected to fall in Brazil in line with falling fertility that would further increase the average saving rate.

To confirm or reject the LCH for Brazil — and to project the most likely trajectory for the future saving rate — are the two main purposes of this section. The section therefore offers a systematic treatment of the partial equilibrium dynamics of household saving rates over the period 2010 to 2050. The analysis builds on the latest 2008 POF household expenditure survey and the PNADE household survey, and a partial equilibrium model is employed to simulate the implications for household saving rates under various scenarios for income inequality. The analysis assumes that saving rates at the household level do not change as a response to aging.

Based on the following discussion, it is found that age-specific saving rates increase up to the age of about 40, after which they remain virtually unchanged on average. As is evident from Figure 1b it matters a great deal to the measure of age-specific saving rates whether or not public pensions are included as part of income. The literature is quite clear on the subject: private pensions should be deducted from the measure of income, but social security pension benefits should not (Bosworth et al., 1991, and Miles, 1999). Mason and Lee (2010) furthermore argue that pensions paid to public workers are components of labor income and simply a cost of producing public goods. As a result, they should be included in the income measure used for evaluating saving rates.

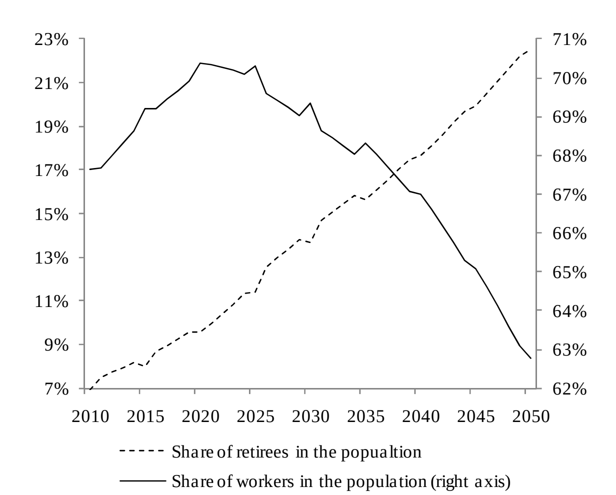
Despite the analyses and views of Bosworth et al. (1991) and Miles (1999), the argument could still be made that gross income over the entire life should not be used to calculate age-specific saving rates — even though private pensions are deducted: A worker's gross income should be deducted any social security contribution that is associated with a PAYG pension scheme, such only his retirement income includes this item. Otherwise, the same income is counted both in the working and retirement-periods, respectively. Therefore, we adjust gross income for private pensions, all taxes, and social security contributions.

Consequently, net income, including public pension benefits, is used for all age groups. Whatever one receives as a PAYG transfer in old age will therefore not be double-counted. The trajectory of the saving rate in Figure 1b, for which income includes public pensions, is therefore assumed to be the correct measure to use; while the measure that excludes public pension benefits is equivalent to evaluating the LCH relative to labor income.

Since the saving rates by age follows the trend in Figure 1b, the LCH is contradicted in the case of Brazil with the key implication that saving rates (and potentially economic growth) will not necessarily be depressed by population aging as would traditionally be expected. This pattern of saving is not unique to Brazil; rather, in several developing countries the saving rates do not decline in old age as they do in most developed countries as suggested by, for example, Poterba (1994), Gregory, Mokhtari and Schrettl (1999), Weil (1997), and Miles (1999). In particular, Attanatio and

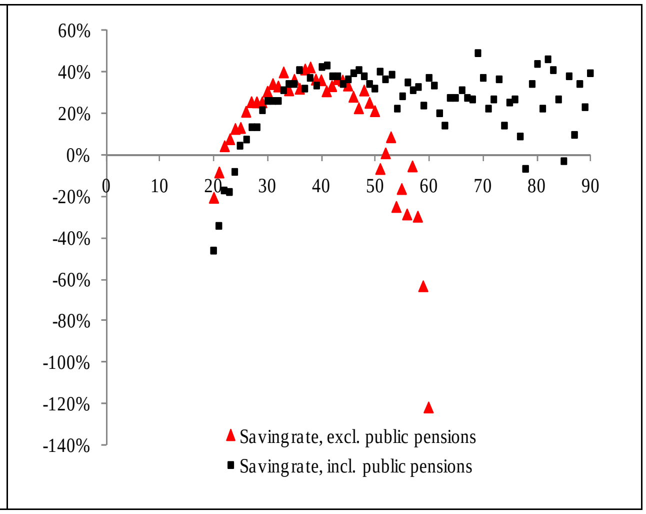
Szekely (2000:38) note in a cross- country study which includes Latin American countries that "a common feature across countries is that we do not find strong evidence of negative saving or even declining saving in the last part of the life cycle in any country".

Figure 1a. Fewer People age 15-65, and More Age 65+ in the Future Brazilian Population



Source: UN Population Division.

Figure 1b. Average Saving Rates Virtually Unchanged after Age 40 — Except if Public Pensions are Excluded



Source: Author's estimations based on POF 2008.[5]

There are several possible explanations for why people save in old age. First, elderly may desire to leave bequests for their working aged children or their grandchildren. The literature on this subject is well explored theoretically by, for example, Barro (1971) and Stokey (1979, 1980). In the case of Brazil, however, there is lacking analytical work on this issue, but there is evidence suggesting that intra-household transfers are from retired elderly to their adult children with whom they cohabitate. Therefore, public pension benefits indirectly end up being a transfer that covers the entire household. The economic implications of such two-sided intra-household transfers are also explored theoretically by, for example, Nerlove and Raut (1997) but, again, not in the case of Brazil. This remains as an issue for future research.

Implications of Income Inequality

Is there more to the story about age-specific saving rates? On average, they remain unchanged after the age of 40, but this aggregate view on age-specific saving rates may hide some important heterogeneity among households in Brazil. In particular, the high income inequality in Brazil may lead to differential saving behavior by income group.

The difference between age-specific saving rates among the non-poor above the poverty line and the poor below the poverty line are illustrated by Figures 2a and 2b. Clearly, there is a crucial difference between the saving behavior of the poor and the non-poor: Despite the fact that the overall pattern is

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[5] After age 63 the saving rates for both the rich and the poor become extremely low, varying between -500 to -23,000 percent. These saving are represented by very few households and are therefore not shown here, but are included in subsequent simulations with the partial equilibrium model.

the same, the poor save much less across each age. The poor also tend to display negative saving after the age of 45 until 65, while the non-poor have positive save rates in this period of their lives. This matter a great deal for the weighted average of the aggregate saving rate since a large fraction of the population in Brazil is between 45 and 65. The negative saving rates among the poor may be difficult to explain, but there may be informal credit possibilities for the poor which are not part of the established financial sector (“agiotas”), which may explain the possibly of negative saving.

Figure 2a. Saving Rates for the Non-Poor follow LCH Except if Public Pensions are Included

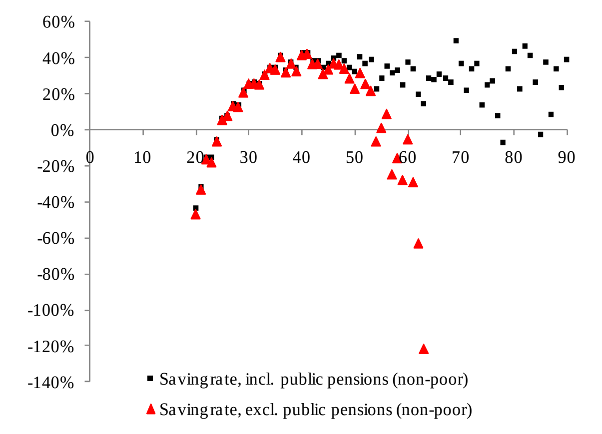
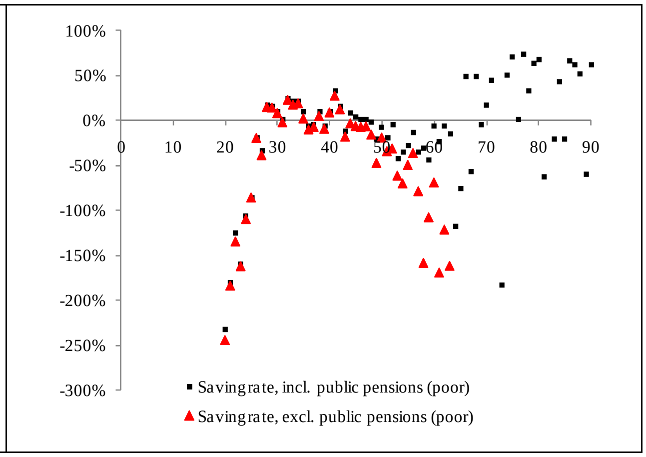


Figure 2b. Saving Rates for the Poor are Lower but Displays the Same Pattern as the Non-Poor



Source: Author’s estimations based on POF 2008.[5]

The simple division of age-specific saving rates across people above and below the poverty line would therefore suggest the saving rate would be positively affected in the future if the share of the population below the poverty line were to falls with its recent trend. In fact, it does not make sense to speculate about future saving behavior without taking income inequality into consideration. Such dynamics are therefore incorporated into the partial equilibrium model employed in the next section.

In 2008, 41 percent of Brazilian families have negative savings, which is 8 percentage points less than in 2002 (Figure 3a). What lies behind this change in saving patterns? Positive savings started at the 74th percentile in 2002 and at the 61st percentile in 2008. This increase in savings for low income percentiles is mainly the result of the increase in income of the poor. Or put differently, the main driver of the increase in saving rates is the decrease in the inequality of Brazilian income distribution which occurred between 2002 and 2008. Figure 3b supports the argument above by illustrating the share of the population below the poverty line for each age-group.

Clearly, there are fewer poor elderly than young. Since the poor save less than the non-poor, we can expect aging to increase the weighted average of the saving rate — all else equal.[6] Such dynamics are also incorporated into the partial equilibrium model to be presented below.

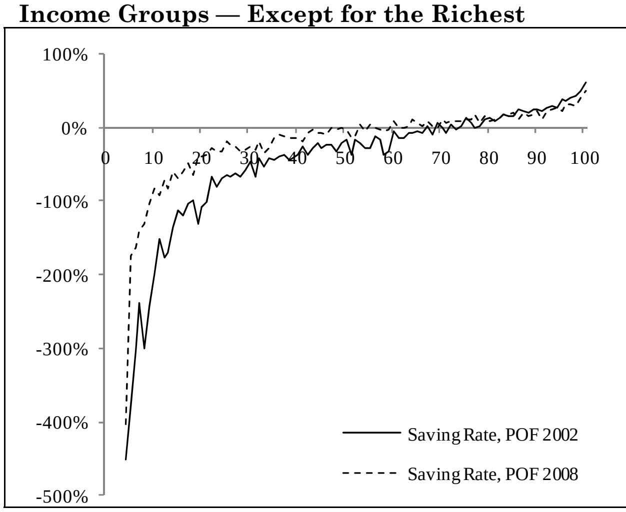
[6] As Figure 3b illustrates, the trajectories for the population across different age-groups will display parallel shifts when the poverty headcount is reduced by, for example, by 1 percent.

Partial Equilibrium Implications of Population Aging

This section will present the partial equilibrium approach to determining the implications of population aging for the household saving rate. The methodology is outlined in, for example, Weil (2000) but is extended to include the important feature of differential saving behavior across income groups.

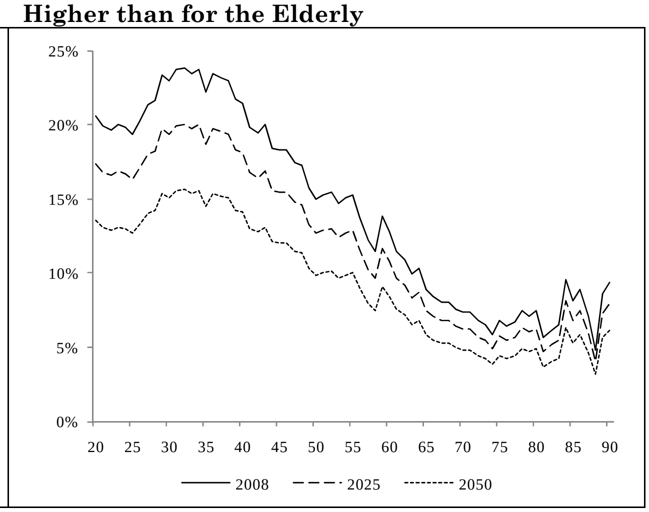
The advantage of the partial equilibrium approach is to exploit the combination of detailed age-specific *population projections* and detailed age-specific *saving rates* available for Brazil — performed across income groups by using scenarios for different inequality levels to determine the projected trajectories for the saving rate. The disadvantage of using this approach is that age-specific saving rates are assumed exogenous, so they cannot change over time when the population experiences lower fertility, lower child mortality, and higher life expectancy.

Figure 3a Saving Rates are Increasing for all Income Groups — Except for the Richest



Source: Author's estimations based on POF 2002, 2008.

Figure 3b. Poverty Rates for the Young are Higher than for the Elderly



Source: Author's estimations based on POF 2008; uniform projections when the share below the poverty line falls by 1 percent.

The question is, of course, whether the saving rate is expected to rise or fall in the future when the population ages, since this will affect economic growth in the same direction. Because each age group in the population saves a certain fraction of its income, it matters for the weighted average of the aggregate saving rate which age groups increase and fall in size. Population aging implies that older age groups increase in size and that they possible live longer due to increased life expectancy. Depending on the size of saving rates of the young, the middle-aged and the old people, such demographic changes are likely to change the aggregate saving rate.

The Partial Equilibrium Model

The main features of the partial equilibrium model used to analyze the future implications of population aging in Brazil. The model is used for simulating the implications for the household saving rate when the population structure changes over the period 2010 to 2050 — combined with scenarios for the share of poor and rich households. The model combines age-specific saving rates;

age-specific population projections; age-specific income distribution relative to the poverty line; and the household saving rate as the starting value for the projections.

Age-specific saving rates

The information about income and consumption is available across age group from the Brazilian POF survey (Pesquisa de Orçamento Familiar), where the household head is taken as the age-reference point when pairing age and saving rate. Only the age-groups above 20 years are used, since the number of households below 20 years are relatively small and are likely to provide unreliable estimates for the saving rate. It is worth noting here that net income is also adjusted by private pension contributions — and as a second scenario, also for public pensions.

Saving rates are found to differ across age-groups between the share of the population above and below the poverty line. The POF 2002 gives similar results, so the latest available 2008 POF data are used. In order to compare we used the average of their preceding ten years for each of the missing years. The equation below indicates how the weighted average of the saving rate is estimated, but the equation illustrates only how it is weighted by people in their youth, middle age, and old age. The estimation is, in fact, done by age. The second to fourth equation show how the saving rate is estimated based on income levels, where the fourth equation indicates the final weighting.

$$s = s_{children}\left(\frac{N_{children}}{N}\right) + s_{workers}\left(\frac{N_{workers}}{N}\right) + s_{elderly}\left(\frac{N_{elderly}}{N}\right)$$

$$s^{poor} = s^{poor}_{children}\left(\frac{N^{poor}_{children}}{N^{poor}}\right) + s^{poor}_{workers}\left(\frac{N^{poor}_{workers}}{N^{poor}}\right) + s^{poor}_{elderly}\left(\frac{N^{poor}_{elderly}}{N^{poor}}\right)$$

$$s^{non-poor} = s^{non-poor}_{children}\left(\frac{N^{non-poor}_{children}}{N^{non-poor}}\right) + s^{non-poor}_{workers}\left(\frac{N^{non-poor}_{workers}}{N^{non-poor}}\right) + s^{non-poor}_{elderly}\left(\frac{N^{non-poor}_{elderly}}{N^{non-poor}}\right)$$

$$s = s^{poor}\left(\frac{N^{poor}}{N}\right) + s^{non-poor}\left(\frac{N^{non-poor}}{N}\right)$$

Population Projections

The population is incorporated for each age and over the period 2010 to 2050 based on the medium fertility variant from the UN Population Division, the 2008 Revision. The data are available on a 5-year interval by age, so Spraque multipliers are used to interpolate for each age. The age-specific population projections are combined with the age-specific share below the poverty line in order to divide the population into a non-poor and poor segment by age group.

Inequality Measure

The share of the population below the poverty line is calculated based on the Brazilian PNADE household survey data for the available years: 1995 to 2007 (except 2000). As inequality scenario 1, the average annual percentage change in the share below the poverty line is used as the future percentage trend change in the share below the poverty line; scenario 2 is a fairly pessimistic scenario with regard to inequality since it is based on zero change in the share below the poverty line. Note that the share below the poverty line is also estimated at an age-specific level, where the share that is poor is seen to shift downwards as the projected share below the poverty line is reduced over time.

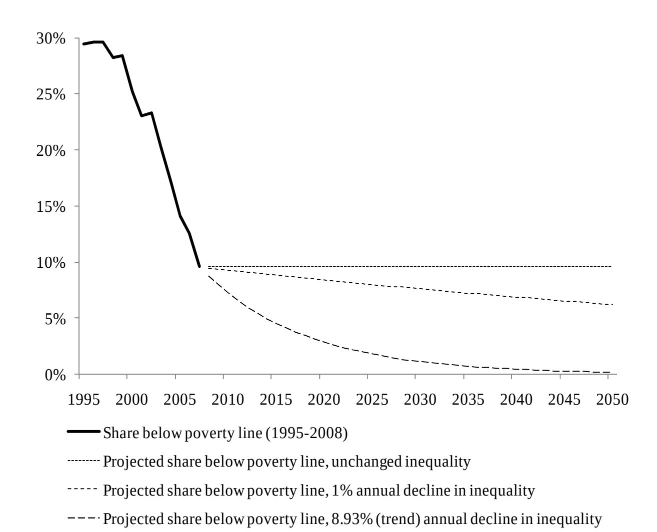
Simulation

The combination of age-specific saving rates, population projections and inequality levels is used for projections of the weighted average of the saving rate. 2006 is used as the initial year for the projections based on IBGE estimates for Families' Saving. The levels of the saving rates are used in the simulations but for the final analysis, the percentage changes in the saving rate are used to project the aggregate family saving rate as it was reported by IBGE at 4.84 percent in 2006. This is because the levels are based on a sample of households in Brazil and may not necessarily be representative to the whole population of non-poor and poor households.

In the simulations, the new rich — the share of the population that would still have been poor if the poverty headcount rate did not fall — are not assumed to save with the full amount as the rich population segment. Instead, we assume that the simple average of the age-specific saving rates for the rich and poor population segments applies to this "intermediate" group. Therefore, it is assumed that the transition from high to low saving rates is phased in line with improvements in the poverty headcount.

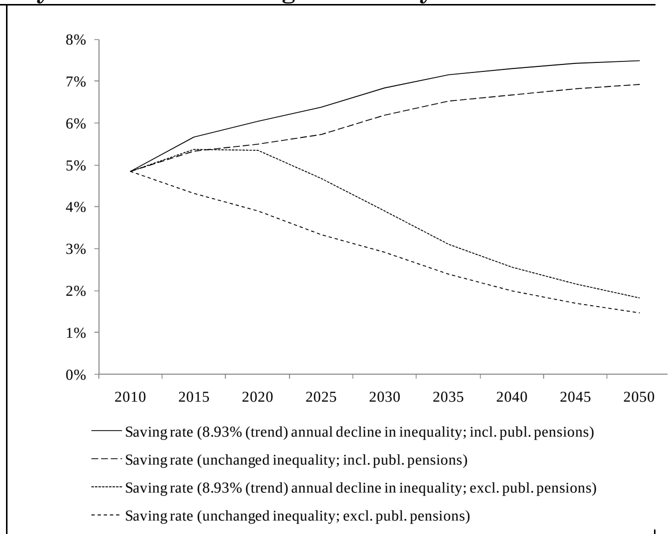
By combining the three types of projections: (i) projections for age-specific saving rate; (ii) projections for age-specific population changes; and (iii) projections for the share that is non-poor and poor, it is possible to project the weighted aggregate saving rate in Brazil. The main finding is that the saving rate may increase slightly from 4.84 to 7.49 percent in 2050 if the poverty headcount follows it trend (as illustrated in Figure 4a). If the poverty headcount remains unchanged, the trajectory of the saving rate will take a parallel downward shift and reach 6.92 percent in 2050.

Figure 4a. Poverty has Fallen from 1995 to 2007; Two Scenarios for Future Poverty Headcount Ratio



Source: Author's estimations based on PNAD survey 1995-2008 for the poverty line of less than $2 PPP in income per day; scenarios for unchanged poverty levels, and 1 percent reduction in poverty.

Figure 4b. Household Saving Rate May Increase by almost 3 Percentage Points by 2050



Source: Author's projections for the saving rate depend on scenarios for poverty and the exclusion or inclusion of public pensions in income.

The projected increase in saving rate is the result of two main factors. First, the change in the population structure leaves larger shares of the population in age-groups that save relatively more. Second, because the share of poor falls with age, the share of the population that is non-poor will increase with time (solid line in Figure 4b) — and this will lead to a higher weight on the saving rates by the non-poor in the average weighted saving rate. If inequality then falls, there will be even fewer poor people — across all age groups but also for the population as a whole. This will lead to an even higher weight on the non-poor's saving rates in the average weighted saving rate.

Robustness and Sensitivity
The baseline scenario for the change in the saving rate, when the population ages, is, as discussed above, illustrated by the solid line in Figure 4b. Three robustness scenarios are then performed: One where public pensions are still included in the estimations of income but where inequality remains unchanged; and two scenarios without public pensions where the poverty headcount either follows the trend or remains constant. These robustness scenarios are also displayed in Figure 4b. If the poverty headcount remains unchanged, fewer people will be saving a higher rate, so the saving trajectory shifts down.

The second and third scenarios testify to whether public pensions should or should not be counted as income which potentially alters the main finding. As Figures 2a,b depict, the saving rates evolve in line with the life-cycle hypothesis if public pensions are no included. Such a saving pattern would generate a weighted average of the saving rate that would fall over time when the population ages. It is our view, however, that these scenarios are not particularly credible, so while we present the implications for illustrative and transparency purposes, we choose rely on the income measurement that includes public pensions — and, thus, rely on the saving profiles that slightly rise over time.

Further robustness tests include whether fertility might be higher or lower than the rate considered in the simulations; whether life expectancy (or age-specific mortality rates) might be higher or lower; and whether the share below the poverty line may increase or fall more than the simulation scenarios reveal. If fertility is higher (lower) than the projected by the UN Population Division's medium fertility variant, there will be a larger (smaller) share of the population in younger age-groups who save relatively less (more), thus reducing (increasing) the weighted average of the saving rate. On the other hand, if the age-structure of mortality changes the share of low-savers to high-savers will also change. In that context, it is more likely that mortality falls relatively more for older age-groups than for younger age-groups — thus increasing the saving rate.

The same argument holds for the share of the population below the poverty line: If the share below the poverty line falls for older age-groups, there will probably be a larger effect on the saving rate than if poverty in youth falls. However, if poverty uniformly falls with the same rate over the entire age-spectrum there will be a relatively larger increase in the saving rate from young savers since a relatively larger share of young live in poverty.

One might also expect the age-specific saving rates to endogenously change in one or the other direction. It is found in the following section that the saving rate might increase if the most prudent policies are put in place for the financing of aging. If an increase in the overall saving occurs, that would translate into considering an overall increase in the age-specific saving rates employed in this section. This may already be occurring, as illustrated in Figure 3a where age-specific saving rates have increased to a non-negligibly extent from 2002 to 2006. Given that saving patterns are perfectly comparable across the two POF surveys, a general tendency in the direction of higher saving across all age-groups will also increase the average saving rate.

If saving rates increase the most for older age-groups, the weighted average of the saving rate is likely to increase substantially since the elderly will constitute a larger share of the population and, thus, be assigned a larger weight in the average saving rate. If the saving rate mainly increases for younger age-groups, there may not be a marked difference in the average saving rate. In conclusion, more research is needed in this area in order to determine the likely implications for saving of changes in age-structures and poverty. However, the main finding from the partial equilibrium analysis is that the saving rate is likely to increase in the future — especially if poverty falls. This, the topic of the next section, depends crucially on whether there will be endogenous changes in age-specific saving rates.

4. Aging, Wealth, and Demographic Dividends

This section provides a general equilibrium (general equilibrium) analysis of the policy challenges and tradeoffs the Brazilian government faces in the context of aging. This analysis complements the partial equilibrium analysis described in the previous section. The partial equilibrium model does not allow households to change their saving behavior as a response to neither aging nor the economic implications aging may have. Instead, households are assumed to display the same economic behavior in the future as they did when the POF household surveys were conducted in 2002 an 2008, respectively.

However, aging is likely to have major general equilibrium implications for household behavior in terms of, for example, consumption, saving, human capital investments, and labor supply. Moreover, macroeconomic responses to aging that endogenously affects growth — such as reductions in the availability of labor in production — were also not taken into account by the partial equilibrium model.

The general equilibrium model captures these behavioral and macroeconomic responses to aging. A general equilibrium model has its own advantages and disadvantages compared to the partial equilibrium model since, in a general equilibrium model, the demographic changes are usually more broadly defined compared to the detailed accounting in a cohort-component demographic model used in the partial equilibrium analysis, and market structures are usually quite crudely defined compared to reality.[7]

In order to capture these behavioral and macroeconomic responses to aging it is therefore necessary to complement the findings from the partial equilibrium analysis with an analysis of aging within a demographic-economic general equilibrium framework. A general equilibrium model has its own advantages and disadvantages compared to the partial equilibrium model since, in a general equilibrium model, the demographic changes are usually more broadly defined compared to the

[7] In terms of the political economy implications of aging, reduced-form relationships will not be stable over time in the face of policy interventions. This is also a version of the Lucas critique (Lucas, 1976) indicating that policy interventions in the future by the Brazilian government may change parameters in the general equilibrium model presented in this section — and this is a general caveat of employing calibrated economic models for evaluating possible policy options (Acemoglu, 2010).

detailed accounting in a cohort-component demographic model used in the partial equilibrium analysis, and market structures are usually quite crudely defined compared to reality.

The General Equilibrium Model [8]

This section describes the main features of the general equilibrium overlapping generations (OLG) model a la Diamond (1965) developed in this paper to analyze the future implications of population aging in Brazil. Agents live for two periods and at each point in time, t, there are two overlapping generations alive, generation t, denoted workers and generation $t\text{-}1$ denoted retirees. These cohorts constitute the economic agents together with the government. The government sector runs a pay-as-you-go (PAYG) pension system and a health system that covers both workers and retirees. In addition, the government is able to issue debt. The purpose of using the model is to simulate the effect on key macroeconomic variables given the projected changes in population aging (population growth and life expectancy) from 2010 to 2050.

The model builds on Jorgensen and Jensen (2010) and features the decisions made by households, firms, and the Brazilian government and the associated economic developments over the life-cycle of a representative agent and firm. Within this demographic-economic framework it is possible to analyze the behavioral and economic implications of population dynamics. The government can then respond to aging with various parametric or structural policies in order to meet its objectives.

An OLG model is appropriate to use in the context of aging because it incorporates the endogeneity of key variables which a partial equilibrium model does not. Therefore, the model addresses the weaknesses of the partial equilibrium model of saving presented above. On the other hand, the weakness of the stylized version of the deterministic OLG model applied here is that is cannot incorporate some key features specific to Brazil — such as endogenous bequests and the complexity of the social security system. It will, however, deliver estimates of the overall direction of the economic implications of aging in Brazil since the model is calibrated with in line with what is believed to be suitable magnitudes of parameters for Brazil. Key structures of the model relating to population aging are as follows.

Demographics

The population grows at a certain rate which falls when the population ages; life expectancy (i.e. the length of the retirement period) is incorporated since aging encompasses both changes in age-structures and in longevity; the population is assumed to either work or to be retired. In each period there are L_t workers and L_{t-1} retirees. There is a constant growth rate of cohorts denoted by $L_t = (1 + n_{t-1})L_{t-1}$.

Households

The representative agent maximizes utility subject to consumption in their working and retirement periods, respectively. In addition, an increase in life expectancy is assumed to lead to higher lifetime utility.

$$U = \frac{C_{1,t}^{1-\sigma}}{1-\sigma} + \phi_t \frac{C_{2,t+1}^{1-\sigma}}{1-\sigma} \qquad (1)$$

[8] The details of the derivations of this model are available upon request.

where, U is lifetime utility; $C_{1,t}$ is consumption in the generation t's working period; $C_{2,t+1}$ is consumption in the retirement period of the same generation t; σ is the inverse elasticity of substitution; and ϕ_t is the (relative) length of the retirement period for generation t (incorporating also the discount rate).

Out of labor income workers decide how much to save and consume given their mandatory contributions to health and pension systems (the two systems most directly fiscally affected by aging); workers' saving leads to investment in this closed economy — which in the next generational period is assumed to be transformed into physical capital used for production; retirees consume the principal and interest on their savings in addition to the pension and health benefits. The intertemporal budget constraint, featuring, the relative prices on intertemporal consumption as well as lifetime income:

$$C_{1,t} + \frac{\phi_t}{R_{t+1}} C_{2,t+1} = \left(1 - t_1 - t_2 + \frac{\psi\phi_t}{R_{t+1}}\right) w_t + h\left(1 + \frac{\phi_t}{R_{t+1}}\right) \quad (2)$$

where, R_t is gross real interest earnings in period t; w_t is the real wage rate; h is the public health expenditures; t_1 is taxes devoted to the public pension system and debt; t_2 is taxes devoted to the public health system and debt; and ψ is the share of real wages received as a public pension annuity.

Firms

Firms employ labor and capital to produce output according to a Cobb-Douglas production function—from which the wage and real interest rate is generated. So, when labor supply falls due to historically lower fertility, the return to labor supply—the now more scarce production factor, increases and the return to capital falls. Aggregate output Y_t is produced by aggregate capital K and effective labor, $A_t L_t$, where $A_t = (1 + g_{t-1})A_{t-1}$ measures the effectiveness of the labor force and L_t is the number of workers all supplying their unit time endowment inelastically. The technology takes Cobb-Douglas form, $Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}$. There is perfect competition of the labor and capital market. It follows that the production factors are rewarded the value of their marginal products. Therefore, the real wage, w_t, and the gross interest rate, R_t, (assuming full capital depreciation) is given by: $R_t = \alpha k_{t-1}^{\alpha-1}$ and $w_t = (1-\alpha)k_{t-1}^{\alpha}$. The exogenous population growth rate is n_t; and g_t is the exogenous technology growth rate between period t and $t+1$.

Government

The Brazilian government manages a pay-as-you-go (PAYG) pension scheme, where workers contribute and retirees receive benefits; and a health system, where workers contribute and both workers and retirees receive the benefits. Both systems depend crucially on the number of workers contributing and the number of retirees (and workers) benefitting. In addition, the government is able to issue debt (domestically). As a result, in each period, the government finances pension and health expenditure as well interest payments on debt and amortization of previous periods' debt. Related to aging is the fact that public debt is essentially the debt of taxpayers, so the fewer taxpayers (workers) there are to bear the debt-burden of previous generations the less sustainable a given level of debt/GDP is. The government debt is reflected by difference between tax revenue and pensions in the consumption level. The dept-output ratio equals $\varepsilon \equiv \mathrm{B_t}/\mathrm{Y_t}$, where B_t and Y_t are aggregate debt and output respectively. Furthermore, $h_t = \pi_t w_t$ is the health replacement rate.

The government budget constraint is stated in the following equation, where the left-hand side is tax revenue and debt in period t which finances the expenditures on the right-hand side which is the reimbursement of last periods debt with interest and the public pension benefit for retirees and health care expenditures — all denoted in units of effective labor,

$$(t_1 + t_2)w_t + b_t = \frac{b_{t-1}R_t}{(1+n_{t-1})(1+g_{t-1})} + \frac{\psi\phi_{t-1}w_t}{1+n_{t-1}} + h\frac{1+n_{t-1}+\phi_{t-1}}{1+n_{t-1}} \tag{3}$$

where b_t is public debt as a share of GDP per worker. Technically there is one equation and three free (policy) variables, τ, Ψ, and ε, where τ is the aggregate contribution rate.

Capital market clears when $K_t = S_t L_t - B_t$, i.e. savings yields interests either in form of capital in firms or by government repaying debt with the same real interest rate. This immediately implies that a higher debt ratio result in lower capital accumulation and therefore the government pays a higher real interest rate.

Calibration

The model is calibrated for Brazil with the following data: Time periods of the model are assumed to be 20 years; as evident from Figure 5a, the population growth rate equals 56 percent (growth rate over the period 1970-1990; UN Population Division); in order to calibrate for life expectancy, the length of the model's first period is normalized at unity while the length of the second period equals 61 percent (estimated as the share of total life spent in retirement: average retirement age equals 57.83 (Queiroz and Figoli, 2010), average entry-age into the labor force is 13.3 (Leme & Malaga, 2001), life expectancy equals 69.3 (average life expectancy at birth over the period 1998-2088, UN Population Division)); the share of capital in output equals 18 percent (average gross capital formation over the period 1990-2010; IMF WEO);

For the base year 2010 in the simulations a debt/GDP ratio of 41 percent (Banco Central do Brazil); the contribution rates to the health system is residually estimated based on 1.46 percent for health benefits (based on health spending/GDP over the period 1984-2009; Tafner, 2010); the contribution rate to the social PAYG pension system is calibrated to 31 percent (11 percent from workers and 20 percent from employers; Queiroz and Figoli, 2010).

The average replacement rate, weighted by the share of the population receiving pension benefits at various rates, for pensions is estimated to be 45 percent. The replacement rate to public servants is assumed to be 95 percent since older public servants participated in a plan of virtually 100 percent replacement rate, while younger generations receive slightly less; the replacement rate for non-public servants is estimated residually based on pension payment data for the two groups; the weighted average is constructed based on the share of the population is each group; the effective weighted average is found to equal 45 percent; sources: DATAPREV, SUB, Plano Tabular da DIIE, and Ministerio da Fazenda. Productivity growth is assumed to follow output growth and equals 168 percent (growth over the period 1988-2008: World Bank GDP); discount rate equals 0.9.

Simulations

The model simulations start in 1990 so the past 20 years of demographic transition is taken into account in projecting the economic implications from the year 2010 to 2050. The model is simulated in Matlab using Dynare software (Jorgensen, 2006). The results should be interpreted as the economic implications over generational periods of 20 years; i.e. over the period 2010 to 2030 and 2030 to 2050. The projections are based on 20-year projections in population growth and life expectancy (UN Population Division).

General Equilibrium Implications of Population Aging

The overall structure of the general equilibrium model encompasses demographics, households, firms, and government. Since aging, broadly speaking, consist of two elements: (i) lower population growth due to reductions in fertility; and (ii) changes in life expectancy due to reductions in mortality, they should be considered as a joint demographic development in any general equilibrium analysis on the economic implications of aging. There are differential economic implications of these two demographic changes, however, and it important to distinguish these in order to identify what drives the aggregate results of the general equilibrium analysis.

Economic implications of lower fertility and, thus, lower population growth: The general equilibrium implications of an isolated drop in the population growth rate — which changes the age-structure of the population over the demographic transition and lead to future aging—is that the capital-labor ratio increases and makes labor a more scarce production factor. This may cause factor prices to change, with upward pressure on wage rates and a downward influence on the return to capital.

A reduction in the population growth rate may also lead to transitory changes in saving behavior as well as labor supply decisions in which case the capital-labor ratio may change even further and amplify the direct effect originating fewer workers. This effect on saving rates is not present in the simulation of saving rates in the partial equilibrium analysis. Importantly, this effect partly leads to the potential *second demographic dividend*, which was found to be positive for Brazil (Mason, 2010).

As a result, the population dynamics that originate from low mortality and fertility endogenously leads to increased saving as the dependency ratio reaches its lowest level. This is due to a higher weighted average of the saving rate due to more people in the working age who have high saving rates and fewer young and elderly who often have lower saving rates. Increased capital accumulation is the implication of this development, which contributes to a second demographic dividend and, at least theoretically, a higher per capita income.

Additional dynamics appear when the government manages systems related to the population structure — in particular pay-as-you-go (PAYG) pensions systems but also health and education systems. Furthermore, Weil (2006) finds that the distortion created by taxes needed to fund PAYG pension systems is a key channel through which a higher dependency ratio affects aggregate output and welfare.[9] In cases where the government decides that pensions or health benefits should be held constant, fewer workers must finance the benefits for more retirees. This leads to fiscal partial equilibrium effects counteracting the higher wages that workers receive due to the aforementioned general equilibrium effects.

If the model includes more features (such as, for example, human capital, and intra-household bequest dynamics) the aggregate effect of changes in population growth will become more difficult to

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[9] There is a large body of literature on the subject of demographic change and viability of social security arrangements (see e.g. Auerbach and Lee, 2001; Campbell and Feldstein, 2001; and Cutler et al., 1990), but this is not the focus of here.

elucidate. The bottom line is that the fiscal partial equilibrium effects are not sufficient to get an accurate measure of the costs of changes in population growth — the general equilibrium effects could very likely be counteracting.

The government may also decide to issue debt to finance some of the aging-bill and, thus, postpone the fiscal burden for future generations. Besides the concerns related to intergenerational equity, such a policy may have other detrimental side-effects in the longer run. For instance, in a (relatively) closed economy, issuing more government bonds drains the financial market which may entail less investment and a lower speed of the accumulation of capital. Increasing government debt from an already high level may cause interest rates on government bonds to increase because investors require a higher risk premium for the risk of default. If the government rolls over the debt, such that the higher interest payments are paid by issuing more debt, then a vicious circle is initiated where defaulting ultimately becomes inevitable.

Economic implications of higher life expectancy: The implications of higher life expectancy is more straight-forward but immensely important in the case of Brazil where it is projected to increase by 11 percent over the period 2010-2050. If people expect to live longer they are likely to increase their saving in order to finance a longer life in retirement. These incentives will lead to an amplified second demographic dividend of increased capital accumulation. A sufficiently high capital-labor ratio is beneficial for welfare since consumption and income will be maximized (the capital-labor ratio can also be too high so it "steals" all the consumption possibilities of households and, thus, eventually reduce welfare).

Again, in an economic environment where the government plays a large role there will be additional partial equilibrium effects of increased life expectancy. For example, in the case of constant pensions for retirees, increased life expectancy will lead to higher contributions on the workers' part (all else being equal in partial equilibrium). However, larger contributions are likely to produce distortionary saving behavior and thus lead to general equilibrium effects through the capital-labor ratio.

Having discussed the appropriateness of a general equilibrium framework in addressing the economic implications of population dynamics, and discussed the qualitative general equilibrium effects that would be expected, the quantitative projections strongly rely on two major issues: (i) how the Brazilian government decides to finance the fiscal costs associated with aging; i.e. the government policy response to aging; and (ii) the magnitude of population changes and the Brazil-specific calibration of the model.

Macro-Policy Responses

The Brazilian government faces a major policy dilemma to address the increasing financial burden associated with population aging. In order to promote welfare and social protection, the government may decide to keep transfers, such as pensions and health benefits, unchanged. But this requires increasing taxes or debt — or cutting expenditures that may not depend on changes in the population structure but still would affect welfare. The government may also decide to reduce public transfers that depend on the population age structure, such as social security transfers and health spending —in order to refrain from increasing taxes or debt or cutting other government programs. Finally, the government may decide to abstain from changing taxes and benefits and simply borrow on financial markets to finance the costs — thereby pushing the burden towards future generations.

The bottom line is that something has to be sacrificed — even taking into account possibly high labor productivity in Brazil in the future.[10]

In other words, in the general equilibrium framework it is assumed that the Brazilian government has three instruments to use: *taxes* (social security contributions and health contributions); *benefits* (social security benefits and health benefits); and *debt* (public sector debt).

The focus here is on the implications of aging for lifetime welfare, lifetime income, capital accumulation, and the saving rate. The government has to react to population aging by formulating a policy response. Even if the government remains passive, that means a continuation of the current policy of high and constant pension benefits. In addition to the policy alternatives presented below, it is obviously possible for the government to cut spending on other programs than those experimented with here, or to raise other taxes than pension and health contributions.

As the partial equilibrium analysis revealed, and as the general equilibrium model replicates, population aging leads to an increasing financial burden. In the general equilibrium model, it is assumed that the Brazilian government has three instruments to use: *taxes* (social security contributions and health contributions); *benefits* (social security benefits and health benefits); and *debt* (public sector debt).

Policy Scenario I: Tax-Financing

It will become fiscally more expensive to have fewer tax payers and more retirees. This is because pension and health benefits bills will increase in size as there are more retirees in need of such services at currently constant replacement rates. Fewer workers would therefore need to finance such benefits—given that replacement rates and debt are assumed to be kept constant. As a consequence of aging there is therefore a larger fiscal burden under such policy assumptions. This is our *Tax-Financing* policy scenario.

Given that tax rates absorb the entire burden—leaving benefits and debt unchanged—it is possible to simulate the implications for the economy. The general equilibrium model is employed for this purpose, and the population projections fed into the model are illustrated in Figure 5a—comprising the projected trajectories for the population growth rate and life expectancy. I find that, in order to keep benefits constant, the social security contribution rate would need increase by 8 percentage points from its current level of 31 percent (11 percent workers' contributions and 20 percent employers' contributions) to 39 percent between 2010 and 2050 (Figure 5b).[11]

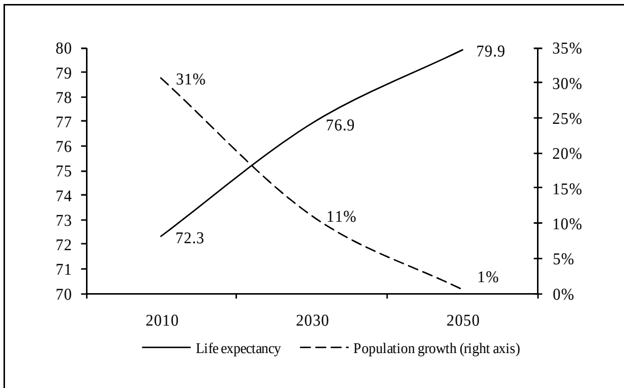
This increase in the pension contribution rate assumes that the health system balances such that fewer workers also finance the health expenditures of more retirees and fewer workers. The

[10] Furthermore, it is not likely that increased oil windfalls will "take care" of the problem, since such commodity revenues are often associated with low saving and investment incentives (Papyrakis and Gerlagh, 2006) or an outright curse for the economy (Sinnott et al., 2010). There is also likely to be important tradeoffs in terms of intergenerational distributions of enhanced consumption possibilities in light of Pré-sal oil and gas windfalls. Jorgensen (2010c) finds that the optimal allocation of oil windfalls is strongly affected by the long term economic implications of population aging, and that aging is a key driver of a policy rule for the efficient and equitable allocation of Pré-sal windfalls.

[11] The system for social security contributions are, naturally, more complicated than simply two rates referred to. However, to make the general equilibrium model tractable, it is assumed that the contributions to the social security system can be reasonably replicated by an aggregate 31 percent contribution rate.

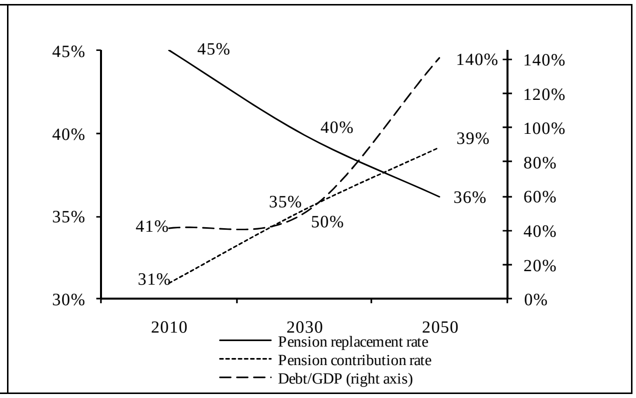
contribution rate for the health system consequently does not rise as much. The aggregate rise in the tax rate to cover constant health and social security benefits is 9.5 percentage points consisting of the 8 percentage points for social security contributions and 1.5 percentage points for health.

Figure 5a. Population Growth is Likely to Slow Down and Life Expectancy will Rise over the Period 2010-2050



Source: UN Population Division.

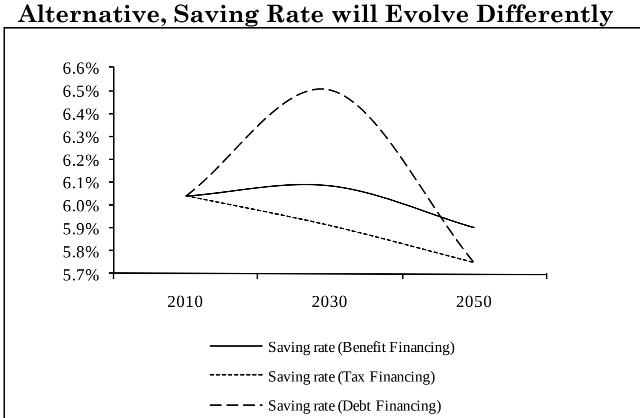
Figure 5b. To Cover the Fiscal Costs of Aging, either Debt or Contributions must Rise, or Benefits must Fall



Source: Author's estimations.

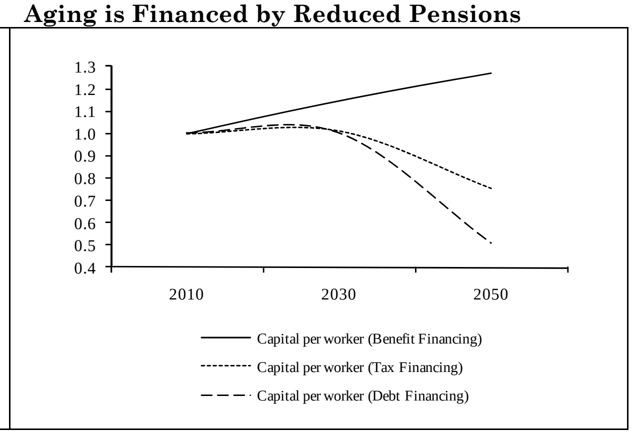
In order to keep benefits constant, the social security contribution rate would need increase by 10 percentage points from its current level of 31 percent (11 percent workers' contributions and 20 percent employers' contributions) to 41 percent (Figure 5b) between 2010 and 2050.[12] This increase in the pension contribution rate assumes that the health system balances such that fewer workers also finance the health expenditures of more retirees and fewer workers. The contribution rate for the health system consequently does not rise as much. The aggregate rise in the tax rate to cover constant health and social security benefits is 11.5 percentage points consisting of the 10 percentage points for social security contributions and 1.5 percentage points for health.

Figure 6a. Depending on the Financing-Alternative, Saving Rate will Evolve Differently



Source: Author's estimations.

Figure 6b. Capital per Worker likely to rise if Aging is Financed by Reduced Pensions



Source: Author's estimations.

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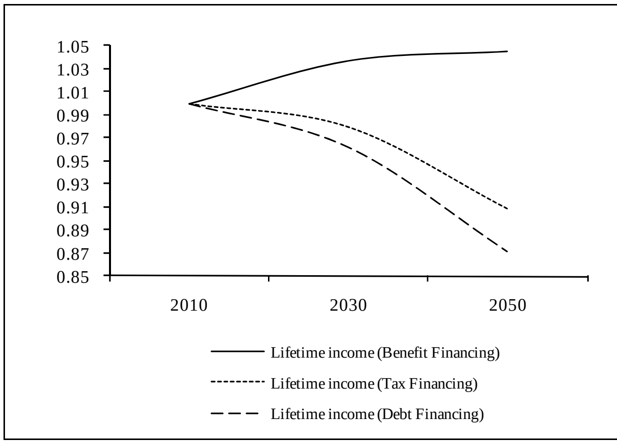
[12] The system for social security contributions are, naturally, more complicated than simply two rates referred to. However, to make the general equilibrium model tractable, it is assumed that the contributions to the social security system can be reasonably replicated by an aggregate 31 percent contribution rate.

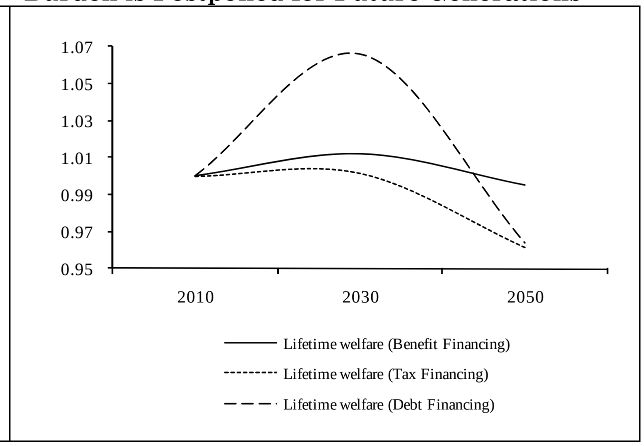
The choice of financing method has economic implications. First, capital accumulation will be further crowded out by the 9.5 percentage points of higher taxes. This means that capital per worker will decline as in Figure 6b. There is a counteracting mechanism, however, since there will be fewer workers in the future and therefore increase the capital per worker ratio. Furthermore, higher life expectancy will have a tendency to increase the saving rate (Figure 6a) and the capital per worker ratio, but these dynamics are all interdependent over the projected period, and as the saving rate starts falling, the steepness of the decline in the capital worker ratio would also increase.

Figure 7a. Benefit-financing will Increase Lifetime Income for each Generation



Source: Author's estimations.

Figure 7b. Lifetime Welfare will Increase if Debt Burden is Postponed for Future Generations



Source: Author's estimations.

A key issue when interpreting the projected trajectory for the saving rate and other macroeconomic variables is the combination of the demographic factors that contribute to population aging. The fall in the population growth rate will generally reduce the saving rate, while the increase in life expectancy will tend to increase the saving rate. The rate of decline in the population growth rate is seen from Figure 1a to decrease over time, so the life-cycle response of the model — in which workers save and retirees do not — will become smaller over time. However, the increase in the saving rate from longer life expectancy will also flatten out over time. The percentage changes are much larger for the reduction in population growth than it is for life expectancy. As a result, over the longer term, the saving rate is projected to fall.

In terms of wealth and welfare, the Tax-Financing scenario will yield a lower lifetime income mainly because increased taxes lead to lower income in people's working life. Also, as net income falls the slightly increased saving rate will not increase aggregate saving sufficiently but reduce it slightly. This is evident from the evolution of capital per worker which fall only a little over the next 20 years but falls faster after that. Consequently, income in old age also falls — rendering lifetime income smaller at an increasing rate. This reduced wealth accumulation corresponds to the simulated path for lifetime welfare in Figure 7b.

The bottom line from the analysis of this Tax-Financing scenario is that capital accumulation and, thus, wealth will fall, which means that this policy choice will negatively affect the second demographic dividend. Saving and the saving rate will eventually fall, and leave less capital per worker. This will in turn reduce lifetime income. Altogether, raising taxes negatively affects welfare.

Policy Scenario II: Benefit-Financing

The results of the Benefit-Financing scenario are based on the same model and therefore include the same demographic and macroeconomic dynamics. The only change from the Tax-Financing scenario described above is that contribution rates for pensions and health are now held constant since the corresponding benefits are now adjusting to the demographic dynamics. As more retirees enter both of the systems in the future, there will be fewer tax payers to contribute with an unchanged rate; there will be more retirees to be covered. Naturally, the replacement rate would need to fall, and the general equilibrium model delivers an approximate magnitude of such a decline in benefits.

The projections reveal that, in order for contribution rates to remain constant, the pension replacement would need to fall by 9 percentage points over the period 2010 to 2050 from 45 percent to 26 percent. This would balance the government budget given that the debt/GDP ratio is held constant. This reduction in pension benefits is accompanied by the need for a simultaneous reduction in the health benefit rate, as the model has been formulated. Clearly, cutting the pension replacement rate by 9 percent is very costly from both a political and social standpoint, but the alternatives may be worse. A pension reform, where adjustments to the age of eligibility to pension benefits, could be considered along with the reduction in the pension replacement rate, since such an indexation mechanism would potentially render the effective labor supply larger and the retirement periods shorter (Jorgensen and Jensen, 2010).

If pension benefits were reduced to the extent proposed by our simulations, there would be several beneficial effects on the economy. Regarding capital accumulation, there would be less crowding out of the current capital per worker ratio if taxes and debt were not increased—so a reduction in benefits would promote a permanently higher capital stock. Furthermore, since lower population growth yields fewer workers and higher life expectancy leads to a higher saving rate (Figure 6a) the capital per worker ratio is bound to rise (Figure 6b).

The effect on lifetime income, when benefits are reduced to accommodate the fiscal pressure, is an outright increase (Figure 7a). Compared to the Tax-Financing and Debt-Financing scenarios the Benefit-Financing scenario is therefore much preferred. Both the working and retirement incomes increase when Benefit-Financing is adopted, and this is again particularly due to changing factor prices and the higher capital labor ratio — and, of course, the unchanged tax payments. Wages will tend to rise as labor becomes the more scarce production factor, and the return to saving is likely to fall. In addition, retirement income does go down due to a lower replacement rate which draws in the opposite direction. Ultimately, lifetime income will tend to rise and lifetime welfare will follow the same pattern — though falling slightly towards the end of the simulation period.

Clearly, the second demographic dividend will be positively stimulated by a Benefit-Financing scenario which is the opposite result compared to the two other alternatives considered. The bottom line is that capital accumulation will be promoted under the Benefit-Financing scenario and this is likely to lead to enhanced wealth and welfare.

Policy Scenario III: Debt-Financing

Under the Debt-Financing scenario, contribution and replacement rates are held constant and the entire fiscal burden of providing for more retirees by fewer workers will be covered by issuing debt. If domestic public debt increases the capital stock will be crowded out even further — and thus worsen the current situation where “only” the large-scale social security system in Brazil neutralizes the incentive to save.

The debt/GDP ratio is seen to explode in Figure 5b over the projected period, 2010-2050, when the population growth rate falls and life expectancy increases (Figure 5a). In fact, debt/GDP is likely to rise by 99 percentage points from 41-140 percentage points. Debt-financing is likely to have devastating implications for capital accumulation and lifetime income (Figures 6b and 7a). The second demographic dividend will therefore be negatively affected. Lifetime welfare, on the other hand, is seen to increase sharply as the current generation of workers realize that all costs associated with aging is merely postponed for future generations to pay off. Over time, however, future generations of workers would need to pay off the debt and welfare then falls quickly as the debt/GDP Ratio might have doubled or tripled by that time.

The bottom line of this Debt-Financing analysis is that current generations of workers are likely to gain in terms of welfare while leaving it to their children and grandchildren to pay off the debt. During this process, capital per worker falls as increased domestic debt crowds out the capital stock. Lifetime income will fall as well—mainly because of reduced production potential due to a large reduction in both factors of production — i.e. the labor force and the capital stock. Ultimately, the choice of debt-financing will be detrimental to the economy and intergenerationally skewed in terms of welfare distributions.

The main conclusion is that the necessary response of any tax or replacement rate is a relatively large increase or fall, respectively, when the population ages. If the social security system is not to be touched, there is awaiting a massive bill for other sectors in the government budget to pay.

Further Policy Implications

In the population aging debate, there is especially one public finance concern: fiscal sustainability. This will not be dealt with explicitly here, but it is worth pointing out that tax policy may not be appropriate since the demographic changes are likely to be somewhat permanent (see, e.g., Oeppen and Vaupel, 2002; UN, 2004). If they had not been of a permanent nature, a tax-smoothing strategy (Barro, 1979) could be an option to overcome the fiscal sustainability concerns, but since they are, in fact, likely to be of permanent nature, some more structural policy measures are called for.

A sensible policy mix could consider the appropriateness of the generosity of the social security system in connection with a reform of entitlement ages to such transfers. The international experience, especially from Scandinavian countries, with longevity-indexed mandatory retirement ages is ample — and theoretically thoroughly analyzed by, e.g., Jensen and Jorgensen (2008a,b).[13] Effective labor supply is very likely to increase when the statutory retirement age increases, because people will (ideally) stay in the labor force for a longer period of time.

Leisure may increase when the statutory retirement age increases, however. This is mainly because there will be less need to save since the retirement period will also be proportionally shorter. More resources will be available for working-period consumption, and since leisure could be assumed to be a normal good, labor supply at the intensive margin is likely to fall (Jorgensen and Jensen, 2010).

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[13] Proposals for using the retirement age as a policy instrument are found in, e.g., de la Croix et al. (2004) and Andersen et al. (2008).

The net effect of labor supply in the model used in this section is simple the represented by the fall in the size of the labor force; since labor supply is not an endogenous variable in this model, and since the retirement age has not been experimented with. For both the former and latter arguments, there is referred to Jorgensen and Jensen (2010), but these issues, in the context of Brazil, are left for future research.

An additional implication of the increase in the retirement age is that lifetime leisure will fall, and this further increases the demand for leisure during the working period. These mechanisms will counteract the increase in effective labor supply from the increase in the statutory retirement age — which is an important endogeneity issue that policy makers should be aware of. Consequently, if policy makers want to achieve a certain increase in effective labor supply from increasing the statutory retirement age, this increase will have to be even higher than initially presumed, since one must account for the endogenous reduction in the intensity of labor supply (Jorgensen and Jensen, 2010). This could also be interpreted as an endogenous drop in the voluntary early retirement age, financed by workers' own savings. This is exactly the opposite of what is intended by a policy rule of increasing the statutory retirement age in line with life expectancy.

Robustness and Sensitivity

When comparing the three alternative financing scenarios considered in this section, it is important to note two issues. First, the model used is not meant to replicate the Brazilian economy perfectly; the model has several shortcomings but is, on the other hand, structured to account for the main channels through which the effects of population aging will be transmitted. It is important to use judgment relative to the models strengths and weaknesses, as discussed below. Second, in addition to the Tax, Benefit and Debt-Financing alternatives, the Brazilian government also has the option of adjusting other taxes or benefits than those considered here.

Behind the general equilibrium result results presented above lies the specific model assumption of a closed economy, where factor payments are endogenous and fully respond to changes in the capital per worker ratio. In reality, Brazil is not a closed economy and the response of factory payments should be adjusted downward to some extent when considering the long term implications of aging. Increased immigration and labor force participation, as well as an increasingly open capital account, would lead to such reductions in magnitudes.

The openness of the capital account, and whether domestic saving turn into domestic investments, are crucial questions. Rodrik (1999) argues that, as a matter of accounting necessity, investment has to be financed by saving, from either domestic or foreign sources: "in an economy investing, for example, 30 percent of its GDP, relying on foreign saving beyond this limit, would imply running a persistent current account deficit in excess of 6 percent of GDP, which would be courting with disaster" (Rodrik, 1999:2). In future research there should be thrown some sand in the wheels of a standardized closed economy model to account for such dynamics in Brazil.

The results remain broadly the same analyzing an open-economy version of the model — depending on whether factor prices are assumed to endogenously change to a full extent (closed economy) or whether they remain completely constant (open economy). Table 4 testifies to the robustness of these results. The main difference in the simulations is the smaller reaction of the debt/GDP ratio in an open economy setting, which is due to real interest rate which will not explode in size when capital accumulation is crowded out by debt issuance that reduces the capital-labor ratio to a major extent. In fact, the real interest rate will not change at all in an open economy setting so the debt/GDP ratio will not be further inflated by higher interest rates on debt service — as it will in a closed economy where the capital labor ratio reacts endogenously — with full pass-through to the interest rate. The "true" response of, especially, the debt/GDP ratio should be found in a hybrid of the closed and open economy versions of the model, and will therefore lie between a 51 and 99 percentage point increase in the debt/GDP ratio by 2050.

Table 4. Simulated Change in Policy-Variables by 2050 (Percentage Points 2010-Value)

- in order to finance the aging induced fiscal costs,	Closed Economy *(percentage points)*	Open Economy *(percentage points)*
taxes would need to increase by:	9	8
or, pension benefits would need to be reduced by:	11	9
or, debt would need to increase by:	99	51

Source: Author's simulations.

The general equilibrium model is structured such that retirees do not save, while retirees in Brazil, in fact, save a lot out of their aggregate income — which includes pension transfers. They do not save out of their labor income, however, thus confirming the life-cycle hypothesis. Bequests and reverse intra-household transfers from retirees to their working aged children — with whom retirees in Brazil often cohabit — should therefore also be incorporated into future research on this topic (Weil, 1997).[14] The large difference in saving patterns across income groups is neither taken into account. Thus, the changes in saving behavior should be adjusted downwards to some extent when considering the negative saving patterns by the share of the population in Brazil living below the poverty line.

In terms of endogenous labor supply, leisure is often considered a consumption-equivalent (normal) good, so labor supply may fall in line with economic growth. This will exacerbate the negative impact on expected labor supply following the decline in fertility but these dynamics are not taken into account (Jorgensen and Jensen, 2008b, 2010). A higher preference for leisure in utility will put upward pressure on savings, the real interest rate, and retirement consumption, as well as downward pressure on working-period consumption and leisure. In fact, Kotlikoff et al. (2001), Welch (1979) and Murphy and Welch (1992) find evidence to support that demographic change affects factor prices, which emphasizes the importance of a general equilibrium model with endogenous real interest rates and wages.

Heterogeneity in Economic Behavior

The high income inequality in Brazil is likely to have important consequences for the possibilities and incentives for saving and investment — as the poorest income groups face somewhat different economic circumstances and incentives that non-poor income groups. This section will analyze the implications of such heterogeneity for economic behavior, capital accumulation, and the second demographic dividend.

[14] There is a growing tendency for elderly people to live along in Brazil, which might lead to a reduced prevalence of the bequest motive. This issue should be taken into consideration in future research on this topic>

The poor part of Brazil's population is still in a situation with high but decreasing fertility and mortality rates (section 4.3).[15] As a consequence of this large difference in demographics between the poor and non-poor segments of Brazil's population, the poor segment deserves an economic modeling that is appropriate to imitate its economic dynamics. In particular, fertility should not be treated as an exogenous variable when the poor population segment is modeled. This is because poor people to some extent use children as an alternative means of saving for old age.

In addition to our personal joy of having children, to which we seem to be more or less genetically programmed (Dasgupta, 1993; p. 356), the motivation for having children can indeed be considered an economic one. Children can provide labor that will benefit the household; they can provide care for parents in old age; and they may be an instrument of altruism from parent to child (Barro and Becker, 1989). Another motivation for having children is the expectation of receiving altruistic intra-household transfers from one's children after retirement (Ehrlich and Lui, 1991; Wigger, 2002; Jorgensen, 2010a,b). Higher capital savings would substitute these intra-household transfers to the effect of lowering the transfer rate and further reduce the need for having children as an old-age security "device".

In order to trace the effects on capital savings, these mechanisms should be accounted for in the model. This is accomplished by endogenizing fertility and altruistic intra-household transfers. A revised version of the general equilibrium model has therefore been developed in Jorgensen (2010a) which considers the special case of an increase in survival rates for both poor children and adults, and traces the effects through the key mechanisms in an economy resembling a developing country. Consequently, the net effect on capital savings may be a decrease because workers may choose to "save" through having more children and, in turn, dis-save through capital. The result in Chakraborty (2004), that improved health conditions will increase capital savings and economic growth, may therefore not hold when the economy is modeled with endogenous fertility decisions and altruistic transfers in accordance with the empirical observations in less-developed countries (Caldwell, 1982).

Simulations for the effects on the household saving rate and per capita income are performed for projected increases in child survival (which increases the size of the labor force) and adult life expectancy (which increases the share of elderly in the population) over the period 2010-2050. An increase in the child survival rate increases the number of dependents and reduces household resources. Furthermore, an increase in adult life expectancy encourages savings, as we expect to live longer. This implies that improvements in child survival should have negative effects on economic outcomes, while improvements in adult life expectancy should have positive effects.

Once three aspects are taken into account: first, the negative fertility response to child survival, second, the possibility of intra-household transfers and, third, the possible compounding effect on capital savings from adult survival due to substitution for less expensive children as a savings mechanism, then we observe that child survival has a net positive effect on capital accumulation. Brought together, the composite change in child survival and adult life expectancy leads to an increase in the saving rate and in productivity growth.

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[15] To be poor is defined in this section as living below the $2 PPP national poverty line.

In this adjusted general equilibrium model, when fertility has declined to a certain level, there will be no altruistic transfers as retirees obtain more and more income through capital savings. When the economy reaches the point in the demographic transition where fertility has declined so much that the only motive for having children is the genetic motive, parents realize that they can no longer save child-rearing resources by switching to capital savings and away from having children as an old age savings mechanism. After this point, an increase in public pensions will reduce the steady state capital stock in line with conventional wisdom. However, while altruistic transfers are still operative, a rise in public pensions increases productivity growth and reduces fertility and therefore speeds up the process by which a country will go through the demographic transition.

As a result, the "savings motive" for having children, facilitated by altruistic transfers, gradually disappears and workers only have children based on the "genetic motive". The model will then collapse to feature a standard general equilibrium model with endogenous fertility. When adult life expectancy then increases further, the impact upon capital savings will be positive, in line with existing literature (e.g. Chakraborty, 2004; Jensen and Jorgensen, 2008a).

In conclusion, the economic dynamics among poor people suggests that saving rates are likely to increase as child and adult survival increases. This will, however, depend on the degree of altruistic transfers from workers to their retired parents. Therefore, the estimates presented above should be adjusted upward — especially when viewed in light of the generous Brazilian pension system which is likely to reduce fertility rates. A complicating mechanism is the reverse transfers from retirees to their working-aged children which is evident among some groups. More research is therefore needed in this area in order to determine the implications of PAYG pension benefits on fertility.

5. Conclusion

Brazil will not necessarily experience a fall in saving, but if government policies are carefully and timely formulated, there is likely to be substantial capital deepening and associated increases in lifetime income, wealth and welfare.

In particular, four issues are likely to boost capital accumulation and thus income per capita over the long term in spite, and as an effect, of aging: First, age-specific saving rates in Brazil show a pattern that does not conform to conventional beliefs regarding life-cycle theory. Saving rates do not fall as people age; in fact, after the age of 40 saving rates remain virtually unchanged on average. This is not too surprising if intra-household bequests and the relatively high public pensions in Brazil are taken into account. Also, it is not uncommon for developing countries to feature high old-age saving rates (Table 3).

A second reason why aging might promote saving is if reductions in poverty and inequality follow their recent downward trends. In this case, more people are likely to display higher savings—in effect increasing the average saving rate. Third, the first demographic dividend of more prime working age savers as a share of the population, combined with higher life expectancy, will lead to capital deepening and the potential of a non-negligible second demographic dividend (Lee, 1994; Lee and Mason, 2007). Fourth, there is also a simple, but important, effect on capital deepening of fewer workers, which mechanically leads to an amplifying effect on the second demographic dividend. As a result, any potentially negative consequences of aging can be abated to a large extent through prudent fiscal and structural government policies — the identification of which is a key objective of this paper.

The main findings from the three complementary methodologies to assess the economic and policy-relevant implications of aging were the following: In relation to the *econometric evidence* for Brazil, a higher saving rate is found to lead to higher income growth; or put more conservatively, there is no econometric evidence suggesting that an increase in the old-age dependency ratio has led to reductions in saving and growth. The *partial equilibrium* results suggest that saving rates in Brazil are found to depend crucially on public pensions, and it is found that if inequality falls then saving will be further promoted because there will be even more high-savers since the non-poor are found to save more than the poor.

In a *general equilibrium* setting, the three scenarios for financing the fiscal costs associated with aging were compared: Benefit-Financing was found to be strongly preferable as a financing method. Reforming the relatively generous Brazilian social security system could advantageously be combined with indexing to life expectancy the age of eligibility for such benefits.

The scope of this paper did not encompass all the transmission channels through which aging will lead to macroeconomic changes. Several issues for future research — both theoretically and in applied research — have been identified in the paper. Notably, the decisions over labor force participation; endogenous changes in effective retirement ages; the institutional settings for harvesting the demographic dividend; and other excluded issues remain for future research on the macroeconomic and economic policy implication of population aging.

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