Research Division
Federal Reserve Bank of St. Louis
Working Paper Series

Generational Policy and the Macroeconomic Measurement of Tax Incidence

Juan Carlos Conesa
and
Carlos Garriga

Working Paper 2009-003A
http://research.stlouisfed.org/wp/2009/2009-003.pdf

January 2009

FEDERAL RESERVE BANK OF ST. LOUIS
Research Division
P.O. Box 442
St. Louis, MO 63166

Generational Policy and the Macroeconomic Measurement of Tax Incidence[1]

Juan Carlos Conesa

Universitat Autònoma de Barcelona

Carlos Garriga

Federal Reserve Bank of St. Louis

January 2009

Abstract

In this paper we show that the generational accounting framework used in macroeconomics to measure tax incidence can, in some cases, yield inaccurate measurements of the tax burden across age cohorts. This result is very important for policy evaluation, because it shows that the selection of tax policies designed to change generational imbalances could be misleading. We illustrate this problem in the context of a Social Security reform where we show how fiscal policy can affect the intergenerational gap across cohorts without impacting the distribution of welfare. We provide a more accurate procedure that only measures changes in generational imbalances derived from policies with real effects.

Keywords: Generational Accounting, Ramsey Taxation

J.E.L. codes: E62, H21

[1] The authors thank the following for useful comments: Costas Azariadis, Tim Kehoe, Chris Phelan, and seminar participants at ITAM, Alicante, Spain; European University Institute, Bern, Edingurgh, the 2008 meetings of the SED, Banco de España, Central Bank Hungary, European Central Bank, CERGE-EI. Judith Ahlers and George Fortier provided great editorial comments. Juan Carlos Conesa acknowledges financial support from Ministerio de Educación (No. SEJ2006-02879), from Generalitat de Catalunya (No. SGR01-00029), Barcelona Economics, and Consolider. Carlos Garriga acknowledges support from the National Science Foundation (grant No. SES-0649374). The views expressed herein do not necessarily reflect those of the Federal Reserve Bank of St. Louis, or the Federal Reserve System. The authors can be reached via e-mail at JuanCarlos.Conesa@uab.es, and Carlos.Garriga@stls.frb.org.

1. INTRODUCTION

The recent financial crises in the United States will leave a huge hole in taxpayers' pockets. The collapse of the investment banking sector and insurance companies, the two largest housing finance entities, and part of the auto industry has required an unprecedented response from the Treasury and the Federal Reserve. The cost of bailout programs designed to restore confidence in the economy have been estimated as 60 percent of gross domestic product (GDP). The magnitude of this figure—in conjunction with the current deficit—has overshadowed the known economic challenges that we face in upcoming years: namely, the imbalance in outlays and incoming revenue for social insurance programs (Social Security and Medicare) caused by the reduction in fertility and the increase in life expectancy. This is in addition to the effects on the labor markets.

The magnitude of these fiscal adjustments can assessed by looking at projected demographics and the distribution of the tax burden across different age cohorts; but, ultimately, policies must by established by considering intergenerational equity (fairness in taxing and benefiting different generations) and economic efficiency.

Thus, before determining who will pay the tax bill for social insurance programs, how much is needed, and the best tax instruments to raise the revenue, we must accurately measure the tax burden or tax incidence of different individuals over time. This measurement then can be used to (i) identify the individuals who are currently bearing the cost of the tax bill and (ii) changes in the tax burden implied by alternative tax regimes. Our paper provides a new and simple metric to measure tax incidence across different age cohorts over time.

The most popular approach to the measurement of generational tax incidence is the generational accounting framework developed by Auerback, Gokhale, and Kotlikoff (1991).[2] The accounting procedure requires rewriting the government's intertemporal budget constraint in terms of the fiscal incidence and the transfer programs received by each generation. Assuming that taxes and transfers remain unchanged, these authors calculate the net tax burden that future generations must bear to achieve long-term balance in the government budget constraint. Any structural change in the tax policy must be captured by a change in the fiscal incidence and transfers received by each generation; this requirement implies a different measurement for present and future generations.

The advantage of the accounting framework is that the tax burden is relatively easy to compute because it does not require specific assumptions about individual preferences, technology, and market structure.[3] It is sufficient to determine an intertemporal discount rate so the tax burden paid by future generations can be directly compared with the current ones. This ease of computation explains the widespread use for policy analysis in practice (Board of Governors, Department of the Treasury, World Bank) to assess the burden of future demographics or the impact of policy reforms. Two limitations of the generational accounting framework are that it ignores the impact of taxation on economic activity, and omits the welfare gains and losses resulting from fiscal reforms. To address these criticisms, Fehr and Kotlikoff (1996) measured the fiscal

[2] Staff economists at the Board of Governors developed a similar approach: a stylized model to measure the impact of population aging on living standards measured using consumption growth. For example, Bernanke (2006) summarizes the findings of Elmendorf and Sheiner (2000) and Sheiner, Sichel, and Slifman (2006) and proposes different alternatives to deal with the demographic transition.

[3] Welfare analysis provides an alternative method to measure tax incidence. This approach requires specific assumptions about preferences and technology and is based entirely on individual optimizing behavior and market clearing conditions. Conesa and Garriga (2008b) use optimal fiscal policy to design the best possible response to demographic shocks.

incidence implied by the generational accounting method in a dynamic general equilibrium life cycle model. They found that generational accounts match the evolution of welfare changes for each cohort, but err with regard to the magnitudes of the change. The authors argue that the bias is quantitatively small when the capital-to-output ratio that determines the equilibrium interest rate and wage rates changes little.

In this paper, we show that the generational accounting framework used in macroeconomics to measure tax incidence can, in some cases, yield inaccurate measurements of the tax burden across age cohorts. This result is very important for policy evaluation, because it shows that the selection of tax policies designed to change generational imbalances could be misleading. We illustrate these issues in the context of tax reforms (i.e. Social Security reform, or tax substitution) where we show how fiscal policy can affect the intergenerational gap measured by the generational accounts without impacting the distribution of consumption, hours worked, and utility. Although cohort costs, measured via the generational accounts, are different, in terms of welfare for the individual they are in fact equivalent. We argue that this is a more fundamental problem with the measure of tax incidence proposed by Auerbach et al. (1991).

Our paper's main contribution is the development of a robust alternative measurement approach based on the same principles and equally simple in its implementation. To solve the aforementioned problems we base the measurement of the tax burden on the consumer intertemporal budget constraint and the notion of effective tax distortions from Ramsey taxation. This concept, instead of considering the statutory definition of taxes (i.e., labor income tax, consumption tax, and capital income tax), uses the notion of tax wedge that distorts relative prices from the marginal rate of transformation. In the absence of distortions, the value of the wedge is one and prices reflect the marginal rates of transformation. The measurement based on the intertemporal budget constraint eliminates the complication of computing the tax treatment of capital income taxation. This intertemporal distortion is embedded in the effective relative price of consumption over time. To illustrate the magnitude of the bias we use a standard life cycle model and compare the generational accounts implied by the baseline model with the ones associated with a Pareto-neutral Social Security reform (as in Conesa and Garriga, 2008a). We find that the bias using the measurement provided by Auerbach et al. (1991) is quantitatively large: The numerical simulations suggest that it can be as high as 15 percent across Pareto-neutral reforms and much larger compared with our alternative measurement procedure. We complete the analysis by providing an empirical illustration that compares the measurements obtained by Kotlikoff (2002) with our definition of generational accounts. We find that the magnitude of the bias is similar to the one obtained in the numerical simulations.

The remainder of the paper is organized as follows. In section 2, we briefly summarize the methodology of generational accounting and its applications. In section 3, we prove our main result in the context of a dynamic general equilibrium model. In section 4, we develop a quantitative policy reform to illustrate the discrepancies in generational accounts, and then provide an empirical illustration for the U.S. economy. In section 5, we summarize the findings and provide our conclusions.

2. GENERATIONAL ACCOUNTING

The generational accounting framework was developed by Auerbach, Gokhale, and Kotlikoff (1991) with the objective of measuring the generational incidence of tax policy independent of fiscal taxonomy labels (see Kotlikoff, 1992, 2001, for a full description of the methodology). The approach compares the lifetime (net of transfers) tax bills between present and future cohorts;, this approach is regularly used to measure the generational impact of changes in fiscal policy. All the different tax burden measures can be compared independent of the method used to calculate fiscal deficits. An important aspect of generational accounting is the impact of the evolution of population demographics in the government budget constraint and the measurement of generational imbalances. The ultimate goal is to prescribe tax policies that could correct any imbalance, so all generations bear a similar tax burden.[4]

Methodology

We closely follow Kotlikoff's (2001) description of the methodology of generational accounting. The tax burden $ga_{t,k}$ in period t of a cohort born in period k is measured as:

$$(1)\quad ga_{t,k} = \sum_{s=\max\{t,k\}}^{k+d} R^{-(t-s)} \frac{\pi_{s,k}}{\pi_{t,k}} TAX_{s,k},$$

[4] A similar concept called equal burden-sharing is used by Bernanke (2006). This concept is interpreted to mean that the current generation and all future generations experience the same percentage reduction in per capita consumption.

where $TAX_{s,k}$ is taxes net of transfers paid at time t by the cohort born in period k, R is a discount factor, $\pi_{s,k} / \pi_{t,k}$ denotes the fraction of individuals surviving at time s, and d represents the life expectancy of a cohort.

Therefore, equation (1) represents the present value of the average amount of taxes paid by the survivors of cohort members born at time k. The tax term includes total taxes paid minus transfer payments of different forms. If we are calculating the generational account implied by a model, all these elements are clearly specified. However, if we are using data as input, the process is a bit more involved (Auerbach, Kotlikoff, and Gokhale, 2001, provide a detailed description of how to map the data into the generational accounts), because it includes expenditures in health care, education, and other forms of transfer programs. However, it does not impute to any specific cohort the value of government expenditure in goods and services. The main reason for this limitation is the difficulty in assigning the benefit of government purchases to different generations.[5]

The government intertemporal budget constraint can then be reinterpreted in terms of generational accounts as follows:

$$(2)\ \sum_{s=0}^{d} \mu_{t,t-s} ga_{t,t-s} + \sum_{s=1}^{\infty} \frac{\mu_{t+s,t+s} ga_{t+s,t+s}}{R^s} = B_t + \sum_{s=1}^{\infty} \frac{G_{t+s}}{R^s},\ t = 1, 2, \ldots,$$

where $\mu_{t,k}$ denotes the measure of individuals in period t of cohorts born at time k. The term $ga_{t,t-s}$ represents the per capita generational account in period t for a generation born in period t-s. The first term on the left-hand side of equation (2) captures the existing

[5] By contrast, welfare analysis can measure the benefits of government purchases when they enter in the production function or in the utility function in the form of public goods.

cohorts, whereas the second term adds the generational accounts of unborn cohorts discounted at a rate R. The term on the right-hand side represents the amount of outstanding government debt B_t (financial liabilities minus the sum of the government's financial assets and market value of public enterprises) and the value of present and future government expenditures. The term G_{t+s} represents the level of government expenditure in period $t+s$.

The choice of the discount rate R merits special attention because it influences the generational accounts for present and future generations. The choice becomes even more problematic in the presence of varying rates or uncertainty because it would require the use of the term structure or the use of some specific stochastic discount factor to adjust for risk. Moreover, in the presence of incomplete markets, risk adjustment should be cohort specific. However, in standard practice a benchmark constant discount rate is used to represent the results under alternative constant discount rates. Assuming a **c**onstant discount rate can be restrictive because the capital-to-output ratio that ultimately determines interest rates may vary in the presence of demographic shocks, or due to different policy regimes.

Generational Accounts Imbalances

Given the tax burden for the current generations and the sequence of future expenditures, it is possible to calculate as a residual the tax payments of future generations. In the presence of imbalances it is possible to compute which policy changes (and paid by which generation) are necessary to restore sustainability.

Another important element is the impact of demographic changes on the imbalance of generational accounts. Consequently, population growth of future generations can reduce imbalances, whereas population aging can exacerbate a larger tax burden on currently young or future cohorts.

Generational accounts are used extensively in the literature to measure fiscal imbalances associated with various tax reforms. For example Gokhale, et al., (2000) analyze the U.S. use of the long-term projections of the Congressional Budget Office. These authors use a 4 percent discount rate and 2.2 percent of productivity growth and find that future generations will face a lifetime burden that is 41.6 percent higher than the existing generations. They propose five alternative policies. The first is a 31 percent permanent increase in federal and personal corporate income taxes. The second is a 12 percent raise of all federal, state, and local taxes. The third policy requires cutting all transfers programs (Social Security, Medicare, Medicaid, food stamps, unemployment insurance benefits, housing support, and so on) by 21.9 percent. The final two options require the reduction of all government expenditures by 21 percent or federal expenditures by 66.3 percent. Other applications include a switch from income to consumption taxation (as in Altig et al., 2001), or Social Security privatization (as in Kotlikoff, Smetters, and Walliser, 2001). The methodology has also been applied to other countries such as the United Kingdom (as in Cardarelli, Kotlikoff, and Sefton, 2000). For an international study, see Kotlikoff and Raffelheuschen, (1991).

3. THE MEASUREMENT OF TAX INCIDENCE

This section begins with two examples in a simple framework. Each example considers standard policy reforms suggested in the literature, such as redistributive policy, or the substitution of consumption taxes by income taxes. We show that these alternative fiscal policies could generate the same household allocation and welfare, but give rise to different measures of tax incidence using the standard generational accounting procedure. We then develop this argument more formally using a fairly general overlapping generations model with production. The model illustrates how the generational accounts can be biased because they are not robust to the choice of tax instruments. The model can also be used to derive an alternative tax burden measurement based on the consumer intertemporal budget constraint. This new measure is equally simple in its implementation and is robust to the choice of tax instruments. We describe these steps in detail.

Examples

Consider a two-period environment in which the households solve a simple intertemporal consumption problem:

$$\begin{aligned} &\max \quad u(c_1)+\beta u(c_2) \\ (3)\quad &s.t. \quad c_1 + a_2 \leq \omega_1 \\ &\qquad\quad c_2 \leq \omega_2 + \left[1+(1-\tau_k)r\right]a_2 \end{aligned}$$

where c_1, c_2 denote consumption, ω_1, ω_2 are the endowments, and a_2 is the asset level.

Because the purpose of the example is to measure the tax burden, we consider specific values for the parameters. In particular, the discount factor is $\beta = 0.5$, the interest rate is $r = 2$, and individuals have an income endowment of $\omega_1 = \omega_2 = 100$ units of the consumption good. The tax policy is entirely characterized by a capital income tax of $\tau_k = 0.5$.

Given the parameter values, it is simple to check that the optimal solution implies: $c_1 = c_2 = 100$ and $a_2 = 0$. Therefore, taxes paid are 0, and the present value of net taxes paid is also 0.

Example 1. Reallocation of resources over the life cycle. A usual example in the literature involves changes in the distribution of resources over time such as Social Security privatization (e.g., Kotlikoff, Smetters, and Walliser, 2001). Consider a policy where households receive a transfer in period 1 of $TR_1 = 50$ and they face a tax of $T_2 = 100$ units in period 2. The capital income tax is kept at 50%.

The reallocation of resources over the life cycle does not alter the households' intertemporal budget constraint, as shown below:

$$(4)\ \ c_1 + \frac{1}{1+(1-\tau_k)r} c_2 \leq \omega_1 + TR_1 + \frac{1}{1+(1-\tau_k)r} \left[\omega_2 - T_2 \right]$$

or

$$(5)\ \ c_1 + 0.5 c_2 \leq 150 .$$

Now, the optimal consumption allocations remains the same ($c_1 = c_2 = 100$), but the optimal level of savings is $a_2 = 50$. What is the present value of taxes net of transfers?

$$(6)\ \ ga = -TR_1 + \frac{1}{1+(1-\tau_k)r} \left[T_2 + \tau_k r a_2 \right] = 50 .$$

The implementation of a tax policy that reallocates resources over the life cycle has no effect on consumer welfare because the intertemporal allocation of consumption has not changed. However, the generational accounts show that the households are paying more taxes.

Alternatively, if we redistribute in the other direction, from young to old (i.e., Social Security), we could implement a tax $T_1 = 50$ in period 1, and a transfer $TR_2 = 100$ in period 2. Since the intertemporal budget constraint does not change, the optimal consumption allocations is the same $c_1 = c_2 = 100$, but now consumers borrow $a_2 = -50$.

Now the implied generational account measuring the present value of taxes net of transfers becomes:

$$(7)\ \ ga = T_1 + \frac{1}{1+(1-\tau_k)r}\left[\tau_k r a_2 - TR_2\right] = -50\,.$$

Not surprisingly, the generational accounting methods show households paying fewer taxes.

This example illustrates a Pareto-neutral Social Security reform that redistributes resources across time. Conesa and Garriga (2008a) show that this neutrality holds even in the presence of labor supply distortions.

Example 2. Substitute consumption taxes for capital taxes. Another typical example in this literature is the substitution of tax instruments (see Altig et al., 2001). Consider a policy where households receive a transfer in period 1 of $TR_1 = 10$, they face a consumption tax in period 2 of $\tau_{c,2} = 0.25$, and the capital income tax is lowered to $\tau_k = 0.25$.

The households' intertemporal budget constraint does not change, as follows:

$$(8)\ \ c_1 + \frac{1}{1+\left(1-\tau_k\right)r}\left(1+\tau_{c,2}\right)c_2 \le \omega_1 + TR_1 + \frac{1}{1+\left(1-\tau_k\right)r}\omega_2$$

$$c_1 + 0.5c_2 \le 150\,.$$

The optimal consumption allocations remains the same, ($c_1 = c_2 = 100$), but the implied level of savings is now $a_2 = \omega_1 + TR_1 - c_1 = 10$. The change in capital income taxation affects the discount rate used to compute the generational accounts over time.

The present value of taxes net of transfers, discounted by the new after-tax interest rate, $\left(1-\tau_k\right)r = 1.5$, is as follows:

$$(9)\quad ga = -TR_1 + \frac{1}{1+\left(1-\tau_k\right)r}\left[\tau_{c,2}c_2 + \tau_k r a_2\right] = 2\,;$$

but, if we were to use the original discounting, it would be

$$(10)\quad ga = -TR_1 + \frac{1}{1+\left(1-\tau_k\right)r}\left[\tau_{c,2}c_2 + \tau_k r a_2\right] = 5\,.$$

Again, consumption—and hence, welfare—do not change, but the tax burden, as measured by generational accounting, increases.

Notably, all of these examples share two common features: alternative fiscal policies redistribute taxes/transfers over the life cycle, and households respond optimally by changing their level of savings. Because the return on savings is taxed, redistribution of the tax burden over the life cycle changes the present value of taxes paid. If, on the contrary, we were to exclude capital income taxes from our calculation of the tax burden, we could immediately see that generational accounting would not change in any of these examples. Now we establish these results in a more general setup.

A Standard Life Cycle Model

Generations live for I periods. Preferences of an individual born in period t are represented by a time-separable utility function of the following form:

$$(11)\quad U(c^t, l^t) = \sum_{i=1}^{I} \beta^{i-1} u(c_{i,t+i-1}, 1-l_{i,t+i-1})\,,$$

where $c_{j,t}$ and $l_{j,t}$ denote consumption and hours worked of individuals of age j at time t. An individual's subjective discount rate is denoted by β. The utility function is assumed to be twice continuously differentiable, strictly concave, monotonically increasing in consumption and leisure, and satisfies the standard Inada conditions. At each time point households are endowed with one divisible unit of time that can be used for work and leisure. One unit of time of a household of age i transforms into ε_i units of labor input. The time-invariant endowment profile of efficiency units of labor over the life cycle is denoted by $\varepsilon = \{\varepsilon_1, ..., \varepsilon_I\}$.

Individuals supply their labor services and assets in competitive markets. Then, individuals receive a competitive wage, w_t, per efficiency unit of labor supplied in period t. They also hold assets, $a_{i,t}$, in the form of physical capital or government bonds in exchange for a market rental rate, r_t. Clearly, the return of both investments must be the same if households are to hold both types of assets. We denote the transfer payments received by cohort j as $m_{j,t}$. Notice that this allows transfers to change over the life cycle.[6]

We assume that markets are complete. Therefore, households are allowed to trade assets to smooth consumption over the life cycle. Two potential extensions from the standard model are possible: (i) the introduction of intragenerational heterogeneity, and (ii) the introduction of mortality risk with or without annuity markets. The findings in this paper do not depend on either of these model features.

The production possibility frontier is represented by a constant returns to scale technology, $Y_t = F(K_t, L_t)$, that transforms units of capital K_t and efficiency units of

[6] We are not restricting the sign of government transfer programs for workers and retirees. This is not relevant since the focus of the paper is the measurement of tax incidence over different cohorts, not the distortionary effect of different tax instruments on these individuals.

labor, $L_t = \sum_{i=1}^{I} \mu_{i,t} \varepsilon_i l_{i,t}$, into value added. The production function is assumed to satisfy the standard Inada conditions. There is no technological progress, and capital depreciates at a constant rate δ . We consider a single representative firm that operates the aggregate technology, taking factor prices w_t, r_t as given.

Each period production can be used for private consumption, investment, and nonproductive government expenditure.[7] We will take the sequence of government consumption to be exogenously specified. The period resource constraint is then expressed as:

$$(12)\ \sum_{i=1}^{I} \mu_{i,t} c_{i,t} + K_{t+1} - (1-\delta) K_t + G_t = F(K_t, L_t) .$$

The government at each period collects consumption taxes, labor income taxes, capital income taxes, and one-period bonds to finance government expenditure and transfer programs. Thus, the period government budget constraint is given by

$$(13)\ \tau_t^c \sum_{i=1}^{I} \mu_{i,t} c_{i,t} + \tau_t^l w_t L_t + \tau_t^k r_t \sum_{i=1}^{I} \mu_{i,t} a_{i,t} + B_{t+1} = \left(1 + r_t\right) B_t + G_t + \sum_{i=1}^{I} \mu_{i,t} m_{i,t} .$$

Definition 1. Given a government policy, a market equilibrium in the economy is a sequence of allocations and prices such that (i) consumers maximize utility subject to their budget constraints, (ii) firms maximize profits, (iii) the government budget constraint is balanced, and~~,~~ (iv) markets clear and feasibility.

[7] We choose to have a non-productive government expenditure to have a comparable benchmark with the generational accounting methodology.

Model Generational Accounts

To construct the generational accounts for each cohort, we must determine the net tax outlets (taxes minus transfers properly discounted) for each generation. In our model environment the generational accounting of every newborn generation is given by

$$(14)\quad ga_t = \sum_{i=1}^{I} \frac{q_{t+i-1}}{q_t} \left[\tau^c_{t+i-1} c_{i,t+i-1} + \tau^l_{t+i-1} w_{t+i-1} \varepsilon_i l_{i,t+i-1} + \tau^k_{t+i-1} r_{t+i-1} a_{i,t+i-1} - m_{i,t+i-1} \right],$$

where $q_1 = 1$ and $q_t = q_{t-1} \dfrac{1}{1+(1-\tau^k_t) r_t}, t = 2,3,\ldots$.

There is also an equivalent expression for the cohorts already born. The generational accounts are not a total lifetime bill, but, rather, remaining lifetime bills. As a consequence the accounts are positive for young and middle age cohorts, but negative for older cohorts.

In contrast with the empirical applications, the theoretical model offers a natural discount rate because the market clearing interest rate can be used.[8] However, it is important to remark that individual generational accounts are just a metric to measure tax incidence and are not necessarily related to the equilibrium in the model. In equilibrium, the government intertemporal budget constraint is always satisfied. However, the implied individual generational accounts and imbalances need not be consistent with the government budget constraint unless the market discount rate is used. We simply use the model to generate data that then are used to measure tax incidence by constructing generational accounts.

[8] Consequently, the long-run effects of demographic shocks or policy changes will affect future discount rates through changes in the capital-to-output ratio. This efficiency effect is usually not captured when the generational accounts are computed directly from the data, and the discount rate is fixed.

4. BIAS IN THE MEASUREMENT OF TAX INCIDENCE WITH STANDARD GENERATIONAL ACCOUNTING

To illustrate the measurement bias of the tax incidence implied by the generational accounts, it is useful to state and prove a well-known equivalence result. We then use this equivalence to show that the generational accounting measurements are not identical across equivalent tax policies.

Proposition 1. Let $(\hat{\tau}, \hat{m}, \hat{B})$ be a feasible fiscal policy, and let $\left\{(\hat{c}_{i,t}, \hat{l}_{i,t})_{i=1}^{I}, \hat{K}_t\right\}$ be the resulting allocation. Then, there exists a fiscal policy $(\tilde{\tau}, \tilde{m}, \tilde{B})$ and a distribution of assets $(\tilde{a}_{i,t})_{i=1}^{I}$ such that $\left\{(\hat{c}_{i,t}, \hat{l}_{i,t})_{i=1}^{I}, \hat{K}_t\right\}$ is the equilibrium allocation corresponding to $(\tilde{\tau}, \tilde{m}, \tilde{B})$. Moreover, the associated generational accounts would in general differ between policy $(\hat{\tau}, \hat{m}, \hat{B})$ and policy $(\tilde{\tau}, \tilde{m}, \tilde{B})$.

Proof. Any equilibrium allocation must satisfy the following first-order conditions:

$$\frac{u_{i,t+i-1}^{c}}{u_{i+1,t+i}^{c}} = \frac{1+\tau_{t+i-1}^{c}}{1+\tau_{t+i}^{c}}\left[1+\left(1-\tau_{t+i}^{k}\right)r_{t+i}\right], \quad i = 1,\ldots, I-1$$

$$-\frac{u_{i,t+i-1}^{l}}{u_{i,t+i-1}^{c}} = \frac{1-\tau_{t+i-1}^{l}}{1+\tau_{t+i-1}^{c}} w_{t+i-1}\varepsilon_i, \quad i = 1,\ldots, i_r$$

$$\sum_{i=1}^{I} q_{t+i-1}\left(1+\tau_{t+i-1}^{c}\right)c_{i,t+i-1} = \sum_{i=1}^{I} q_{t+i-1}\left(1-\tau_{t+i-1}^{l}\right)w_{t+i-1}\varepsilon_i l_{i,t+i-1} + \sum_{i=1}^{I} q_{t+i-1}m_{i,t+i-1}.$$

Clearly, more than one policy can implement the same allocation because there are $2*I$ equations and $4*I$ fiscal variables to determine a given an allocation.

Given an alternative fiscal policy, assets can then be constructed directly from the sequential budget constraints. Notice that aggregate wealth would then change, and as a consequence, government debt changes because the aggregate capital stock is unchanged. Finally, the new level of government debt must necessarily balance the government budget constraint by Walras' law.

In general, the associated generational accounts measurement would change, even though allocations and welfare are the same. To see that the generational accounts must change for at least one generation, recall equation (2):

$$\sum_{s=0}^{d}\mu_{t,t-s}ga_{t,t-s}+\sum_{s=1}^{\infty}\frac{\mu_{t+s,t+s}ga_{t+s,t+s}}{R^{s}}=B_t+\sum_{s=1}^{\infty}\frac{G_{t+s}}{R^{s}},\ t=1,2,\dots .$$

Notice that because aggregate debt in general changes across equivalent policies, the right-hand side of the equation must change for some t. Therefore, the left-hand side must change as well.■

This result has two important implications.[9] From the positive point of view, the measurement of tax incidence implied by generational accounts does not provide an accurate description (or invariant metric) of generational imbalances of the effective tax burden faced by different cohorts. From a normative point of view, the evaluation of tax policies based on the distribution of tax burden for different age cohorts could be misleading of the true cost for each cohort. Our results show that we could be evaluating the implied tax incidence of different policies on different cohorts and using the generational accounts to conclude that one policy performs better than another**.** Nevertheless, these policies could be equivalent from the household perspective, but the

[9] A few remarks are relevant to the proposition. First, notice that the different tax reforms consistent with the proposition might imply a change in statutory tax rates (with the same effective tax wedges), a change in the magnitudes of intergenerational transfers, or both. Second, the result still holds in the presence of borrowing constraint of some form. The proof is very general and holds in a larger class of economies that include uncertainty and certain forms of market frictions. It is sufficient to have a non-empty set of equivalent policies.

generational accounts would lead to a different conclusion. This should be clear from the examples in Section 3 that show the influence of tax reform in generational accounts imbalances.

Correcting the Bias in Generational Accounting

A major problem in using generational accounts to measure generational imbalances is the tax treatment of savings. The main result from Proposition 1 states that any equivalent tax policy that requires a different distribution of asset holdings that include claims on capital and government debt will lead to different generational accounts.

One way to avoid this problem is to measure tax incidence using the intertemporal budget constraint and effective rather than nominal tax distortions. The idea is very simple: If the tax policies are equivalent, the intertemporal budget constraints must be the same; otherwise, consumption-leisure plans would differ. Given this condition, then, we should measure the magnitude of all the effective taxes paid using the consolidated budget constraint and not what is recorded in the government accounting books. This alternative procedure can be described as follows. Consider the sequential budget constraint:

$$\begin{aligned} & q_{t+i-1}\left(1+\tau^{c}_{t+i-1}\right)c_{i,t+i-1}+q_{t+i-1}a_{i+1,t+i} = \\ & q_{t+i-1}\left(1-\tau^{l}_{t+i-1}\right)w_{t+i-1}\varepsilon_i l_{i,t+i-1}+q_{t+i-1}\left[1+\left(1-\tau^{k}_{t+i-1}\right)r_{t+i-1}\right]a_{i,t+i-1}+q_{t+i-1}m_{i,t+i-1} \end{aligned} \quad (15)$$

Define $\tilde{q}_{t+i-1}=q_{t+i-1}\left(1+\tau^{c}_{t+i-1}\right)$ and $1-\phi_{t+i-1}=\dfrac{1-\tau^{l}_{t+i-1}}{1+\tau^{c}_{t+i-1}}$.

Newborn households' intertemporal budget constraint can be written as follows:

$$(16)\ \sum_{i=1}^{I} \tilde{q}_{t+i-1} c_{i,t+i-1} = \sum_{i=1}^{I} \tilde{q}_{t+i-1} \left[\left(1-\phi_{t+i-1}\right) w_{t+i-1} \varepsilon_i l_{i,t+i-1} + \frac{m_{i,t+i-1}}{1+\tau^c_{t+i-1}} \right].$$

Notice that the difference between the market value of labor income and consumption, valued at the effective price of consumption goods, is denoted as:

$$(17)\ \sum_{i=1}^{I} \tilde{q}_{t+i-1} \left(w_{t+i-1} \varepsilon_i l_{i,t+i-1} - c_{i,t+i-1} \right) = \sum_{i=1}^{I} \tilde{q}_{t+i-1} \left[\phi_{t+i-1} w_{t+i-1} \varepsilon_i l_{i,t+i-1} - \frac{m_{i,t+i-1}}{1+\tau^c_{t+i-1}} \right].$$

Undoing the transformation of variables in the right-hand side of equation 17, we arrive at our proposal for measuring tax incidence across cohorts:

$$(18)\ GA_t^{IBC} = \sum_{i=1}^{I} \frac{q_{t+i-1}}{q_t} \left[\left(\tau^c_{t+i-1} + \tau^l_{t+i-1} \right) w_{t+i-1} \varepsilon_i l_{i,t+i-1} - m_{i,t+i-1} \right].$$

Notice that two equivalent policies must satisfy the following first-order conditions (and the intertemporal budget constraint):

$$(19)\ \frac{u^c_{i,t+i-1}}{u^c_{i+1,t+i}} = \frac{\tilde{q}_{t+i-1}}{\tilde{q}_{t+i}}$$

and

$$(20)\ -\frac{u^l_{i,t+i-1}}{u^c_{i,t+i-1}} = \left(1-\phi_{t+i-1}\right) w_{t+i-1} \varepsilon_i .$$

It is then clear that equivalent policies should therefore generate the same fiscal burden as measured by equation (18), because the relative price of consumption across periods, the effective taxation of the consumption-leisure margin, and the effective present value of transfers must be the same across equivalent policies.

Thus, we have provided an alternative measurement of tax incidence that is robust to the choice of tax instruments to decentralize a given allocation. Moreover, it is even simpler in practice, as shown in the following direct comparison (equation 21) between our proposal and the standard procedure (equation 22):

$$(21)\quad GA_t^{IBC} = \sum_{i=1}^{I} \frac{q_{t+i-1}}{q_t}\left[\left(\tau^c_{t+i-1} + \tau^l_{t+i-1}\right) w_{t+i-1}\varepsilon_i l_{i,t+i-1} - m_{i,t+i-1}\right]$$

versus

$$(22)\quad ga_t = \sum_{i=1}^{I} \frac{q_{t+i-1}}{q_t}\left[\tau^c_{t+i-1} c_{i,t+i-1} + \tau^l_{t+i-1} w_{t+i-1}\varepsilon_i l_{i,t+i-1} + \tau^k_{t+i-1} r_{t+i-1} a_{i,t+i-1} - m_{i,t+i-1}\right].$$

Notice that the same procedure could be used for currently existing cohorts. The only difference is that for these cohorts the taxation of currently existing wealth holdings should be included as effective taxation, while this is not the case for newborns born with zero assets.

5. QUANTITATIVE ASSESSMENT OF THE TAX INCIDENCE BIAS

In this section we measure the potential size of the tax incidence bias and compare it ~~to~~ with our proposed robust measure. In general, it is difficult to characterize the equilibrium path and the optimal decision rules for a given tax policy. In the absence of a closed-form solution, we use numerical methods to simulate the policy reforms and compute the implied generational accounts.

As an illustration, we perform a Pareto-neutral Social Security privatization that transforms the unfunded system into a funded one with private accounts following Conesa and Garriga (2008a). The tax incidence bias can be measured as the difference between the implied generational accounts across Social Security regimes and by comparing the magnitudes with the robust measure.

Parameterization

Next we determine the choice of functional forms and parameters for the model simulation.

Functional forms. We pose a standard log utility function between consumption and leisure:

$$(24)\ u(c,l) = \gamma \ln c + (1-\gamma)\ln(1-l),$$

where γ represents the consumption share on the utility function.

The aggregate technology is Cobb-Douglas with constant returns to scale:

$$(25)\ F(K,L) = K^{\alpha} L^{1-\alpha},$$

where α represents the capital income share in output. We assume that capital depreciates at a constant rate δ and there is no exogenous technological growth.

Population structure and income. A model period is equivalent to one year. Given our period choice, we assume households live for 65 periods, so that the economically active life of a household starts at age 20 and we assume that households die with certainty at age 85. In the benchmark economy, households retire in period 45 (equivalent to age 65 in years). Finally, we normalize the mass of households to be 1. We assume that households are endowed with one unit of time. The lifetime profile of efficiency units is constructed using Current Population Survey (CPS) data.

Government policy. The level of government expenditure is exogenously specified as 20 percent of output. Revenues come from two sources: (i) capital and labor income taxes and (ii) consumption taxes. In addition, the government runs a pay-as-you-go Social Security system in the benchmark policy scenario. We assume that the tax on capital income is 33 percent, Social Security contributions are 10.5 percent, and consumption taxes are 5 percent. The labor income tax is chosen to balance the government budget given the target level of outstanding government debt.

Given the assumptions on the functional forms, endowments, and tax rates, we jointly solve for the equilibrium and the parameterization using the minimum distance method. Table 1 defines the parameter values and the targets.

We want our economy to match three empirical targets. First, we define aggregate capital as the level of fixed assets in the Bureau of Economic Analysis statistics, giving an implied capital-to-output ratio of 3.00. Our second target is the average number of hours worked over the life cycle, with an average of one-third of the time of households allocated to market activities. The third target is an investment-to-output ratio of 16 percent. In addition, we fix government debt (defined as federal, state, and local) with an implied ratio to GDP of 0.50, and the ratio of government expenditure to GDP at 0.20.

Our three targets determine the value of three parameters: the discount factor, the consumption share in the utility function, and the depreciation rate. In addition, the labor income tax is endogenously determined from the government's budget constraint given the ratios of government debt and expenditure to GDP.

A Pareto-Neutral Social Security Reform

The fiscal reform we examine follows Conesa and Garriga (2008a), and it illustrates the measurement discrepancies generated by the standard procedure of generational accounting. The goal is to implement a privatization of the Social Security system while maintaining the level of distortions from the baseline economy.[10] The timing of events works as follows. We assume that at time 1 the economy is in steady

[10] Clearly, it is possible to achieve better policy results optimizing distortions as in Conesa and Garriga (2008a) that use optimal fiscal policy to do precisely that.

state with an unfunded Social Security system. The contributions made by the young generate an entitlement to a future benefit retirement, which constitutes an implicit debt of the Social Security Administration towards them. On retirement, these retirees receive their claims.

The reform is implemented at $t = 2$. The government eliminates pensions, giving compensatory transfers to all households. These household-specific transfers are financed with government debt. The privatization effectively transforms the implicit debt of the Social Security system into explicit debt, but real allocations and welfare remain unchanged. The resulting distribution of wealth is different, since now Social Security implicit claims are transformed into explicit assets in the hands of households. Figure 1 compares both distributions of wealth.

The asset distribution under the funded system is always above the unfunded one, since now workers use the proceedings from Social Security contributions to invest in private savings accounts. The youngest cohort receives as a transfer an initial level of assets that is equivalent to the net present value of Social Security transfers. This number ensures that the consumer intertemporal budget constraint is satisfied. The difference between the newly issued government bonds and the initial outstanding government debt determines the implicit debt of the Social Security system. Figure 2 represents the net taxes paid over the life cycle in these two equivalent policy regimes.

Under the unfunded Social Security system, the entire tax burden is placed on individuals age 65 and younger. Retired households pay consumption and capital income taxes, but in net terms they receive resources (their pensions). Under the new regime, retired households do not receive a transfer from the government, and they are fully taxed for the interest earned in the retirement accounts. Despite the differences in the amount of taxes paid, the welfare distribution is the same across tax regimes. Using the net taxes paid and the relative size of each cohort, we can compute the generational accounts of each cohort based on their age. Figure 3 summarizes the model implied generational accounts for these two equivalent Social Security regimes using the standard approach.

Notice that the standard generational accounting procedure is not invariant between these two equivalent policy regimes because the two top curves in Figure 3 do not lie on top of each other. To the contrary, the implied values have a bias that can be as high as 15 percent for the young and middle-aged cohorts. The bias is driven purely by the fact that government bond holdings are larger in the funded regime, while they are not net wealth. Because capital income (coming from holding government debt or financial assets) is taxed, the imputed tax burden varies across the two policy regimes. However, the proceedings from selling the government bonds are by construction equal to the transfers received from the Social Security system. The distinction is that under the equivalent policy, transfers are computed as a taxable asset and a liability for the government that remains forever, whereas in the other case as a net transfer from the government and funded by workers' contributions (but an implicit liability for the government). Next, we compare this standard measurement with our proposed robust measure for generational accounts.

The generational accounting procedure we propose is based on the intertemporal households' budget constraint and therefore accounts only for the tax treatment of capital and consumption insofar as they affect the relative price of consumption across time. Also, the measure only considers the effective distortion in the labor supply net of the government transfers received in the corresponding period. As a consequence, the new measure predicts a lower tax burden for all households except households in their last period.

Notice the large bias of the previous two generational accounts (GA) (“GA Funded” and “GA Unfunded”) compared with the proposed generational accounting metric based on the intertemporal budget constraint. We claim that our proposed new metric is not only robust to the choice of tax instruments, but it is also easier to calculate because it requires less information.

An Empirical Illustration

The previous results were illustrations with data generated from a model. Now we complete the analysis by comparing the measurement of tax incidence according to our proposed procedure with the measurement by Kotlikoff (2002, table 1). Kotlikof’s table reports the generational accounts of males in the United States in 1998, measured in thousands of dollars, under the assumptions of a 4% discount rate and a 2.2% growth rate.

Figure 4 illustrates the quantitative difference between the original methodology and our proposal. We use the numbers reported in Kotlikoff’s table 1 (2002) to construct our alternative measure. We subtract the capital income taxes that all cohorts would have to pay in the future and include only the taxation of initial wealth holdings. A simple comparison shows that the effective taxation of the existing cohorts in 1998 is much lower than with the traditional methodology. The results are very consistent with the findings implied by the model. In particular, the model and the data estimates suggest that the zero crossing point should be delayed 10 years.

5. CONCLUSION

The current financial crisis is taking a huge toll on government deficits. In addition, current estimates anticipate that in 25 years the U.S. economy will have twice as many retirees but only 20 percent more workers. This demographic transition surely will have an important effect on the government budget unless the benefits from Social Security and Medicare are reduced. The determination of which cohorts will bear the cost is important, but first agreement on how to measure generational imbalances is needed.

We show that the standard generational accounting procedure yields an inaccurate measurement of tax burden imbalances across cohorts. We find that it is possible to construct tax policy reforms consistent with the same pattern of consumption, work effort, and utility across generations, but yielding different tax burden measurements than those obtained with generational accounting. This result is very important for policy evaluation because it shows that the selection of tax policies based on generational accounts can be biased. We quantify the potential bias introduced by the methodology at the same time that we provide a robust alternative, equally simple in its implementation.

REFERENCES

Altig, D., L.J. Kotlikoff, K. Smetters, and J. Walliser. (2001). "Simulating Fundamental Tax Reform." *American Economic Review*, June 2001, pp. 574-95.

Auerbach, A.J., and L.J. Kotlikoff. (1987). *Dynamic Fiscal Policy*. Cambridge: Cambridge University Press.

Auerbach, A.J., J. Gokahale, and L.J. Kotlikoff. (1991). "Generational Accounts: A Meaningful Alternative to Deficit Accounting," in D. Bradford, Ed., *Tax Policy and the Economy*, vol. 5, pp. 55-110. Cambridge, MA: MIT Press.

Bernanke, B. (2006). "The Coming Demographic Transition: Will We Treat Future Generations Fairly?" Presented at the Washington Economic Club, Washington, DC, October 4, 2006; www.federalreserve.gov/newsevents/speech/bernanke20061004a.htm

Cardarelli, R., L.J. Kotlikoff, and J. Sefton. (2000). "Generational Accounting in the UK." *Economic Journal*, *110*(467), pp. 547-74.

Conesa, J.C., and C. Garriga. (2008a). "Optimal Fiscal Policy in the Design of Social Security Reforms." *International Economic Review 49*(1), pp. 291-318.

Conesa, J.C., and C. Garriga. (2008b). "Optimal Response to a Transitory Demographic Shock," in De Menil, G., R. Fenge and P. Pestieau, Eds. *Pension Strategies in Europe and the United States,* pp. 87-113. CESifo-MIT Press. Cambridge, MA.

Elmendorf, D., and L. Sheiner (2000). "Should America Save for Its Old Age? Fiscal Policy, Population Aging, and National Saving." *Journal of Economic Perspectives*, *14*, pp. 57-74.

Fehr, H., and Kotlikoff, L.J. (1996). "Generational Accounting in General Equilibrium." *FinanzArchiv*, *53*(4), pp. 1-27.

Gokhale, J., B. Page, J. Potter, and J. Sturrock. (2000). "Generational Accounts for the U.S.—An Update." *American Economic Review*, *90*(2), pp. 293-96.

Kotlikoff, L.J. (1992). *Generational Accounting: Knowing Who Pays, and When, for What We Spend*. The Free Press. New York.

Kotlikoff, L.J. (2002). "Generational Policy," in Auerbach, A.J., and M. Feldstein, Eds., *Handbook of Public Economics*, pp. 1983-1932. Amsterdam: North Holland.

Kotlikoff, L.J., K. Smetters, and J. Walliser. (2001). "Distributional Effects in a General Equilibrium Analysis of Social Security," in M. Feldestein and J. Liebman, eds., *The Distributional Effects of Social Security Reform.* Chicago: University of Chicago Press.

Kotlikoff, L.J., and B. Raffelheuschen (1991). "Generational Accounting Around the Globe." *American Economic Review*, *89*, pp. 161-66.

Sheiner, L., D., Sichel, and L. Slifman (2006). "A Primer on the Macroeconomic Consequences of Population Aging." Finance and Economics Discussion Series Working Paper, Board of Governors of the Federal Reserve System, Division of Research and Statistics, September 2006; http://www.federalreserve.gov/pubs/feds/2007/200701/200701pap.pdf.

Figure 1. Asset Distributions (relative to yearly income)

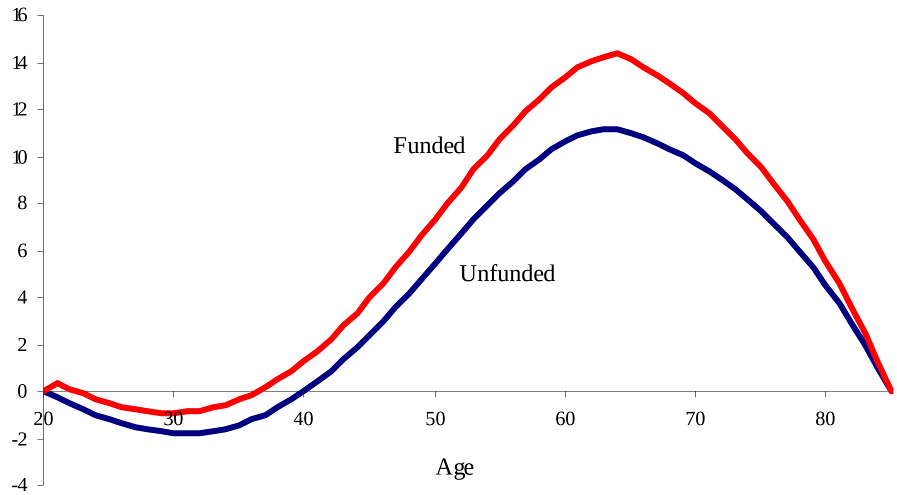

Figure 2. Net Taxes Paid (relative to yearly income)

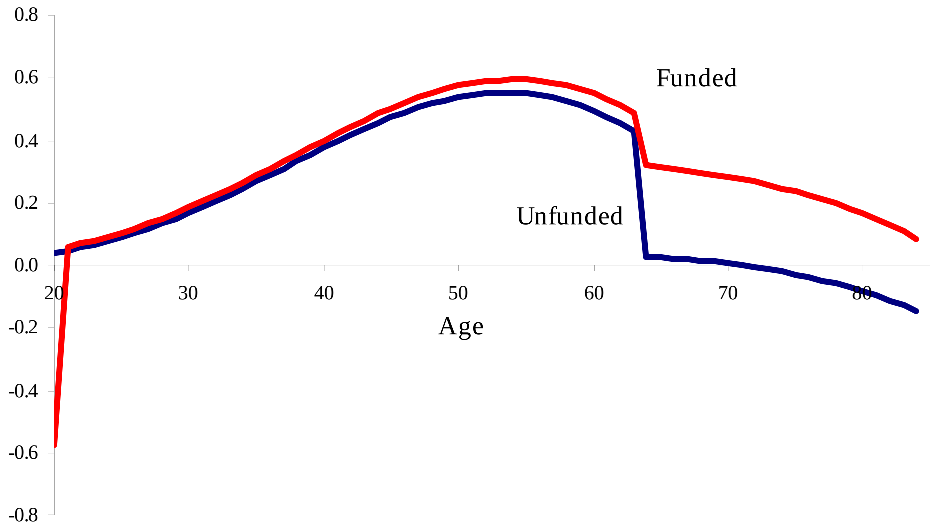

Figure 3. Generational Accounts (relative to yearly income)

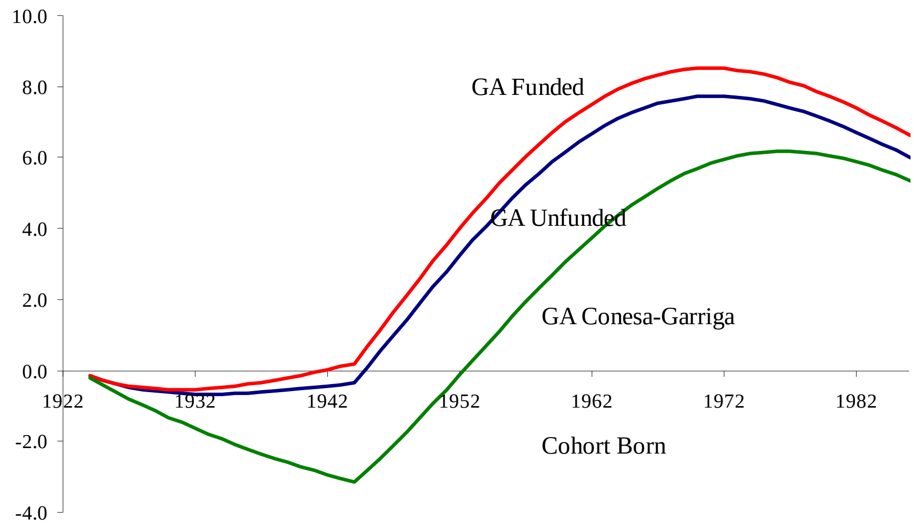

Figure 4. Generational Accounts (thousand dollars 1998)

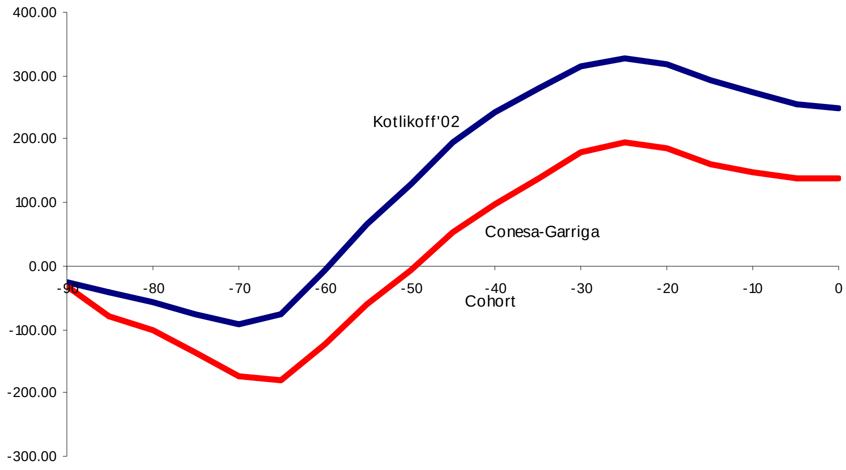

Table 1. Parameterization of the Economy

Statistic	Target	Result
Wealth to GDP ratio	3.00	3.00
Investment to GDP	0.16	0.16
Average Hours Worked	0.33	0.33
Debt to GDP	0.50	0.50
Government Expenditure to GDP	0.20	0.20
Variable	**Parameter**	**Value**
Discount factor	β	0.984
Consumption share	γ	0.460
Depreciation rate	δ	0.041
Labor income tax	τ^l	0.169