

# How Should Unfunded Social Security be Financed?\*

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## Abstract

The U.S. Social Security program is almost entirely financed with payroll taxes. However, other taxes exist that could be used (at least partially) to finance Social Security benefits. *Without* arguing in favour of the old and controversial idea of reallocating general tax revenue to finance Social Security, in this study a different question is asked: What type of economic activity is it more appropriate to tax in order to finance a given level of pension benefits, while preserving the current Social Security system's benefit entitlements and pay-as-you-go nature, and not altering its legislated distributional aspects? To answer this question we build a calibrated general equilibrium model with rational and inattentive (low-saving) agents, uncertain longevity, income heterogeneity, endogenous retirement, Social Security, non-payroll taxes and productive government spending. We find that lowering the payroll tax and refinancing Social Security with higher consumption taxes improves the welfare of the rich, factor prices and raises the GDP, while the welfare of the poor is nearly unaffected. Despite potential concerns that in an economy where a sizable fraction of the population saves very little, making it unlikely for the capital stock to increase sufficiently in response to higher consumption taxes, we find this is not the case in the general equilibrium environment with endogenous retirement.

**JEL Classification:** H55, E21, E62, D58

**Key Words:** Social Security, General Revenue, Taxation, Lifetime Uncertainty, Rule-of-thumb, General Equilibrium

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# 1 Introduction

The United States has the largest pay-as-you-go Social Security system in the world, which is almost exclusively financed by the payroll taxes imposed equally on employers and employees. However, other taxes exist that could be used (at least partially) to finance Social Security benefits. Different types of taxes cause different types of distortions to labor supply, saving and thus imply different general equilibrium effects. It is not obvious which economic activity would be best to tax in order to finance a given level of aggregate Social Security benefits.

This paper computes the optimal financing of Social Security when the policymaker is free to use a variety of non-payroll taxes. Within our model it has been found that when higher consumption taxes are used to finance a cut in payroll taxes, welfare generally improves for everyone. The latter result arises even though a fairly large (but realistic) fraction of the model's population consists of inattentive savers, whose saving rate would always remain low.

These conclusions have been reached by building a calibrated general equilibrium model with the following baseline features. It is a continuous-time, overlapping generations economy, populated with heterogeneous agents, facing uncertainty in regard to their longevity. Economic agents have different earnings abilities and are of two types: rational and rule-of-thumb savers, both optimally deciding when to retire, however. In the baseline scenario, the government runs a balanced pay-as-you-go Social Security program, financed by payroll revenues. Unlike many studies in this line of research, which assume that the government spending is mainly consumptive, the non-payroll tax revenues (from consumption tax, capital tax, wage earnings tax (different for the poor and for the rich), and the bequest tax) in this study are allowed to augment the productivity of private capital in the manner of Barro (1990), Glomm and Ravikumar (1994) and many others. With a reasonable degree of approximation, our study is able to replicate several salient features of the U.S. economy, such as the realistic capital-output ratio, gross pre-tax real rate of return on capital, fraction of the government revenues in GDP, median retirement age, poor-to-rich ratio of pension benefits, and a well-documented discrete drop in aggregate life-cycle consumption at the time of retirement. The model is then used to investigate the welfare effect of alternative financing schemes for the pension program, while preserving its core features.

At first, it might appear that we are arguing in favour of general revenue financing of Social Security, which many policymakers and the general public have long been concerned about, believing that Social Security must be funded by its own unique tax. As President Roosevelt stated, "We put those payroll contributions there so as to give the contributors a legal, moral, and political right to collect their pensions and unemployment benefits. With those taxes in there, no damn politician can ever scrap my social security program."<sup>1</sup> We are sympathetic to that argument, but are not actually considering general revenue financing of Social Security in this paper. We simply ask: If one can tax a single economic activity in order to fund a given amount of pay-as-you-go benefits, what should that activity be?

This paper makes a contribution to the literature that has mostly focused on the optimal size of the

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<sup>1</sup>It is worth mentioning here, that technically, the U.S. Constitution does not prohibit the Federal government from ever scrapping the Social Security program altogether. Aside this issue, one concern, which is often articulated by opponents of general revenue financing of Social Security, is that then the current universal insurance nature of the U.S. pension program might vanish as the pay-as-you-go program is turned into a means tested welfare program with all the associated problems of asymmetric information. Fiscal discipline can theoretically be undermined as well.

Social Security program<sup>2</sup> and not on how to finance a given level of aggregate benefits. A somewhat related (albeit different) issue has been investigated by Kotlikoff et al. (2007), who consider the option of pre-funding Social Security benefits with higher taxes on consumption and wages during transition to a new steady-state, where the Social Security benefits are eventually phased out, that is future retirees will not receive any pension benefits.<sup>3</sup> Huang et al. (1997) consider switching to a fully funded Social Security system to be financed via the government-acquired claims on physical capital, or buying-out (via a massive public debt) the initial retirees who are alive when social security payments are suddenly terminated. Conesa and Garriga (2008) analyze whether it is possible to generate a Pareto-neutral social security privatization by altering some distortive fiscal parameters and compensating the initial cohorts in a lump-sum manner along the transition path to the new steady-state, with transfers being financed via new debt. Smetters and Walliser (2006) consider the possibility of allowing people to opt out of a pay-as-you-go program to elicit private information about their heterogeneous skill levels, while general revenues are used to pay for the transition. Unlike these studies, we do not consider a pension reform, nor do we focus on cases where Social Security benefits will be scrapped (even partially).

Our results can be summarized as follows. When a decline in payroll taxes is compensated by a rise in a non-payroll tax to prevent aggregate pension benefits from falling, the economy cannot achieve a superior competitive equilibrium through an increase in capital, wage or bequest taxes. However, if Social Security is refinanced with higher consumption tax revenues, the rich would experience non-trivial welfare gains at nearly every level of the corresponding payroll tax reduction, while it can be safely concluded that the poor would not be worse-off. Totally eliminating payroll tax and increasing consumption tax from the baseline 5.5 percent to 15.84 percent, would be equivalent to increasing yearly baseline consumption of the rich and the poor by approximately 3.36 and 0.07 percent, respectively. Accumulated aggregate capital stock would rise by 6.49 percent relative to the baseline, and the corresponding wages and total GDP would increase by 2.08 and 2.45 percent, respectively. The rich would choose to retire approximately 1.68 months later, while the poor would retire approximately by 4.44 months later than they currently do. Our results line up nicely with many traditional findings in the literature, highlighting a positive role of higher consumption taxes in an economy facing various non-payroll revenue-neutral fiscal reforms, often experimenting with a complete elimination of the Social Security program as such (see, e.g., Fuster, et al. (2008) and the references therein).

The rest of the paper is organized as follows. Section 2 presents a formal model, and in Section 3 the model is calibrated to some of the salient features of the U.S. economy. Section 4 considers the refinancing of Social Security with new general revenue, and briefly discusses the findings. Section 5 concludes.

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<sup>2</sup>Refer, for instance, to Feldstein (1985), Docquier (2002), İmrohoroğlu et al. (2003), Cremer et al. (2008), and the references therein.

<sup>3</sup>The economic impact of public pensions under different financing mechanisms has been previously considered in alternative settings. For instance, Lambrecht et al. (2005) focus on two ways to finance a public pension program (via lump-sum taxes or proportional labor taxes) in a model where parents face a trade-off between leaving bequests and investing in their heirs' human capital. The focus of their paper is growth, rather than welfare maximization.

## 2 A General Equilibrium Economy with Life-cycle and Rule-of-Thumb Consumers

This section outlines some basic features of our model. First, the model is cast in continuous time and calendar time is indexed by  $t \in \mathbb{R}$ . An individual enters the workforce at birth, and his planning horizon spans till the maximum number of years  $T > 0$ . An individual agent who is born at time  $t = \tau$  is called a member of cohort  $\tau$ . At each instant, a new cohort is born and the old cohort dies and exits the model. To simplify the analysis, we abstract from the growth rate of population and assume that at each instant in time a cohort of size  $N$  is born.

Second, the model will be populated with perfect-foresight (rational) and rule-of-thumb agents, both facing an uncertain lifetime. The lifetime is a random variable with the probability of surviving until age  $t - \tau$  or beyond given by a survival distribution  $Q(t - \tau)$ . The hazard rate of death (mortality risk) is  $m(t - \tau) \equiv -\frac{d \ln Q(t - \tau)}{dt}$ . Our survivorship function will take the sextic polynomial form proposed in Feigenbaum (2008).

Third, both types of agents will have exactly the same preferences over lifetime consumption and leisure. Rational agents will maximize their lifetime utilities by choosing the consumption rate at each instant, *and* total amount of labor they supply during their lifetime. Agents will derive utility from consumption,  $c(t; \tau)$ , piecewise continuous leisure path,  $l(t; \tau)$ , and the corresponding utility function is given by  $u(c(t; \tau), l(t; \tau)) = \sigma \ln c(t; \tau) + (1 - \sigma) \ln l(t; \tau)$ , where  $\sigma \in (0, 1)$  is a parameter that captures the trade-off between consumption and leisure in the instantaneous utility function.

We assume agents rather decide at what calendar time to retire, while their leisure consumption is exogenously fixed at some low level ( $l_- \in (0, 1)$ ) during the working life, and at a high level ( $l_+ = 1$ ) during the retirement phase. In other words, individuals decide *when* to switch from  $l_-$  to  $l_+$ . By endogenizing the date of retirement this way, we are endogenizing the total labor supply of the agent.

Rule-of-thumb agents, on the other hand, will consume a fixed fraction of their wage earnings (possibly all wage earnings), but will still have to optimally decide when to retire. This type of Keynesian rule-of-thumb attitude towards saving can be linked to inattentiveness of one form or another, although it does not necessarily imply irrationality.

Fourth, each agent will be endowed with a stream of productivity units which will be increasing in age early in lifetime, and decreasing in age later in lifetime. A poor agent's efficiency endowment will be everywhere lower than that of the rich agent. We will define the productivity function by borrowing the quartic polynomial form proposed in Feigenbaum (2008).

Fifth, because lifetime is uncertain, following Bullard and Feigenbaum (2007) and Feigenbaum (2008), a deceased agent's wealth is assumed to be spread uniformly across his surviving brethren. Thus, at time  $t$  a surviving agent receives a bequest of size  $B(t)$ .

Sixth, in our model the government is going to generate both payroll and non-payroll tax revenues from taxes on consumption, capital, wages and bequests. Collected revenues will be partly redistributed back to the agents, and partly will be used as a public infrastructure investment. Although in our model the government does not observe who is rational and who is rule-of-thumb, the government observes whose wage earnings are high, and whose are low. Thus, the labor income tax and transfers can, in principle, differ across the agents. The government will also run a pay-as-you-go Social Security program. Upon retiring, everyone receives a constant flow of Social Security benefits, which depends on a time of retirement and the socioeconomic status of the agent. Since we assume that the agent is "born" and enters the workforce at age 25, time  $t = \tau + 37$  would imply that he has

turned 62, which is the earliest pension eligibility age in the United States. Having outlined these basic features of our model, we are now ready to turn to the specific details.

## 2.1 Rational Agents

The rational consumer solves

$$\begin{aligned} \max_{\{c(t;\tau)\}, T_1} & \left[ \int_{\tau}^{\tau+T_1} Q(t-\tau)e^{-\rho(t-\tau)}[\sigma \ln c(t;\tau) + (1-\sigma) \ln l_-] dt \right. \\ & \left. + \sigma \int_{\tau+T_1}^{\tau+T} Q(t-\tau)e^{-\rho(t-\tau)} \ln c(t;\tau) dt \right], \end{aligned} \quad (1)$$

subject to:

$$\frac{dk(t;\tau)}{dt} = (1-v_r)rk(t;\tau) + \Psi_1 - (1+v_c)c(t;\tau) + (1-v_B)B(t), \text{ for } t \in [\tau, \tau+T], \quad (2)$$

$$\Psi_1 = \begin{cases} (1-v_{w_1} - \theta)wh_1\epsilon(t-\tau)(1-l_-) + \varphi_1, & \text{for } t \in [\tau, \tau+T_1] \\ b(T_1), & \text{for } t \in (\tau+T_1, \tau+T] \end{cases}, \quad (3)$$

$$k(\tau; \tau) = 0, \quad (4)$$

$$k(\tau+T; \tau) = 0, \quad (5)$$

$$b(T_1) = \begin{cases} z_0 + \frac{z_1}{1+e^{z_2-z_3T_1}}, & \text{if } T_1 \geq 37 \\ 0, & \text{if } T_1 < 37 \end{cases}, \quad (6)$$

where  $\rho \in \mathbb{R}_{++}$  is the discount rate,  $T_1$  is the number of years since birth that the rational agent works and earns wages,  $k(t;\tau)$  is the private savings account at time  $t$  of an agent from cohort  $\tau$ ,  $v_r$  is the tax rate on capital income,  $r$  is the market-determined risk-free gross interest rate,  $v_c$  is the proportional tax rate on consumption,  $v_{w_1}$  is the wage income tax rate faced by the rational agent,  $\theta$  is the Social Security payroll tax, and  $v_B$  is the inheritance tax rate on the instantaneous bequest,  $B(t)$ . Here  $\epsilon(t-\tau)$  is a cohort-independent (hump-shaped) function of age, capturing the evolution of the agent's efficiency endowment over time (see Gourinchas and Parker, 2002; Feigenbaum, 2008, for details). The exogenous parameter  $h_1$  captures the rational agent's innate ability, or human capital endowment. The real wage per labor efficiency unit,  $w$ , is determined competitively within markets. The rational agent receives a transfer from the government,  $\varphi_1 \equiv \beta_1 wh_1 \epsilon(t-\tau)(1-l_-)$ , where  $\beta_1$  is constant. For example, if  $\beta_1 \in (0, 1)$ , then the agent receives positive transfer payments from the government proportional to his wage earnings.

Social Security benefits,  $b(T_1)$ , received by the rational agent, depend on the date of retirement, and are given by the step function (6), where  $z_1$ ,  $z_2$  and  $z_3$  are all strictly positive and exogenous parameters, while  $z_0$  is a scale parameter to be determined endogenously in general equilibrium to balance the Social Security budget. The logistic function for ages 62 and older closely resembles the actual U.S. benefit formula (see Caliendo and Gahramanov, 2010, for details).<sup>4</sup>

<sup>4</sup>Notice that we have explicitly assumed that pension benefits are untaxed, which is not true in reality, and especially not for high-income earners. We will partially account for such a simplifying assumption by adjusting the pension benefit ratio between rich and poor later on in the calibration section.

The fixed end-point optimal control problem (1)-(6) with an endogenous switch point,  $T_1$ , is solved in two stages. *Stage 1*: Fix  $T_1$  and solve (1)-(6) for the optimal consumption,  $c_{T_1}(t; \tau)$ ; *Stage 2*: Let  $T_1$  take any value from  $[0, T]$  in  $c_{T_1}(t; \tau)$ , and calculate the corresponding value of the lifetime utility function. Optimal retirement date ( $T_1^*$ ) will correspond to the value of  $T_1$  at which the lifetime utility is maximized.

Appendix A shows that the optimal consumption profile from Stage 1 is given by

$$c_{T_1}(t; \tau) = \frac{\sigma Q(t - \tau)}{\Omega(1 + v_c)e^{(\rho - r(1 - v_r))t - \rho\tau}}, \quad (7)$$

where  $\Omega$  is determined by (A.14).

Next, in Stage 2, the date of retirement is endogenized by maximizing the objective function, while setting consumption equal to its corresponding value from (7). Hence,

$$T_1^* = \arg \max \left[ \sigma \int_{\tau}^{\tau+T} Q(t - \tau)e^{-\rho(t-\tau)} \ln c_{T_1}(t; \tau) dt + (1 - \sigma) \int_{\tau}^{\tau+T_1} Q(t - \tau)e^{-\rho(t-\tau)} \ln l_- dt \right]. \quad (8)$$

Taking factor prices and the model parameters given, the rational agent will optimally choose at what age to exit the labor force, which is  $T_1^* + 25$ . Having said that, we now turn to the rule-of-thumb agents.

## 2.2 Rule-of-Thumb Consumers

A rule-of-thumb consumer is assumed to save a fixed fraction,  $s \in [0, 1]$ , of only after-tax wage earnings. Therefore, the agent's savings account evolves according to the following differential equations and end-point conditions:

$$\frac{dk(t; \tau)}{dt} = (1 - v_r)rk(t; \tau) + \Psi_2, \text{ for } t \in [\tau, \tau + T], \quad (9)$$

$$\Psi_2 = \begin{cases} s(1 - v_{w_2} - \theta)wh_2\epsilon(t - \tau)(1 - l_-), & \text{for } t \in [\tau, \tau + T_2] \\ -\Gamma, & \text{for } t \in (\tau + T_2, \tau + T] \end{cases}, \quad (10)$$

$$k(\tau; \tau) = 0, \quad (11)$$

$$k(\tau + T; \tau) = 0, \quad (12)$$

where  $\Gamma$  is determined by (B.5) (see Appendix B) and stands for the constant annuity withdrawal that drives the savings account to zero at the maximum age. Here  $v_{w_2}$  is the wage income tax rate faced by the rule-of-thumb agent,<sup>5</sup>  $h_2$  is an exogenous parameter describing his level of human capital, and  $h_2 < h_1$  is assumed. That is, rule-of-thumb agents are assumed to earn less income. Although there is strong evidence that low-income earners save relatively less in the U.S.,<sup>6</sup> we should mention that in reality the farsighted individuals and the myopic ones can either be high-income or low-income

<sup>5</sup>The government might or might not set  $v_{w_2}$  equal to  $v_{w_1}$ . Although the government does not observe who is rational and who is not, the government in our model does observe wage earnings, and thus can decide the value of  $v_{w_2}$  and  $v_{w_1}$  in any manner it deems necessary.

<sup>6</sup>See Duflo et al. (2006) and the references therein.

earners (Cremer et al., 2009). Finally, the rule-of-thumb individual will retire at date  $T_2$ , and this choice is endogenous, as will be described below.

By virtue of a simple rule-of-thumb, the agent consumes as follows:

$$c_{T_2}(t; \tau) = \frac{1}{1 + v_c} [\Psi_3 + (1 - v_B)B(t)], \quad (13)$$

$$\Psi_3 = \begin{cases} (1 - s)(1 - v_{w_2} - \theta)wh_2\epsilon(t - \tau)(1 - l_-) + \varphi_2, & \text{for } t \in [\tau, \tau + T_2] \\ \Gamma + b(T_2), & \text{for } t \in (\tau + T_2, \tau + T] \end{cases}, \quad (14)$$

where

$$b(T_2) = \begin{cases} x \left[ z_0 + \frac{z_1}{1 + e^{z_2 - z_3 T_2}} \right], & \text{if } T_2 \geq 37 \\ 0, & \text{if } T_2 < 37 \end{cases}, \quad (15)$$

and  $x \in (0, 1)$ . In the U.S. the rich receive larger Social Security benefits than the poor retiring at the same age, but generally the rich get a smaller gain from Social Security. The poor receive more benefits than is justified by their own earning and contribution capacity. Expression (15) assumes that the government will design the pension benefit structure such that the ratio of the poor's benefit to the rich's benefit is always  $x$  for  $T_1 = T_2$ . Note that given the value of  $h_1/h_2$ , we can appropriately choose the value of  $x$  to mimic the current redistributive role of the Social Security program in the U.S. Observe that, in reality, a relatively wealthy retiree, retiring, say, at age 62, would receive smaller monthly pension benefits than a relatively poor retiree, retiring at age 70. Our specification of the benefit structure allows for such a possibility.

The rule-of-thumb agent receives transfers  $\varphi_2 \equiv \beta_2 wh_2 \epsilon(t - \tau)(1 - l_-)$ , for each year of the working period, which is immediately consumed ( $\beta_2$  is constant here). The rule-of-thumb agent chooses retirement age optimally (in general, a rule-of-thumb agent can choose to retire at a different age from a rational agent), given that his consumption is determined by (13). Hence, the agent chooses  $T_2$  according to

$$T_2^* = \arg \max \left[ \sigma \int_{\tau}^{\tau+T} Q(t - \tau) e^{-\rho(t-\tau)} \ln c_{T_2}(t; \tau) dt + (1 - \sigma) \int_{\tau}^{\tau+T_2} Q(t - \tau) e^{-\rho(t-\tau)} \ln l_- dt \right]. \quad (16)$$

Note if we set  $s = 0$ , we get  $\Gamma = 0$ , meaning that during retirement the rule-of-thumb agent will have to rely just on Social Security benefits and some accidental after-tax bequests.

### 2.3 Aggregation and General Equilibrium

We now close the model by endogenizing factor prices, and focus on steady-state equilibria. Gross output is assumed in the form of

$$Y = K^\alpha L^{1-\alpha} G^\eta, \quad (17)$$

where  $Y$  is total income,  $K$  is the total stock of private capital,  $L$  is the aggregate labor supply measured in the efficiency units,  $G$  is the aggregate amount of productive government purchases, and  $\alpha, \eta \in (0, 1)$ . Considering public services as an input to production closely follows Barro (1990), Glomm and Ravikumar (1994), to name a few.<sup>7</sup>

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<sup>7</sup>Plausible assumptions of congestion, rivalry and exclusiveness associated with public capital are not considered here. The reader can refer to Glomm and Ravikumar (1994; 1997) and references therein for discussion of these issues.

Recalling that consumers have been divided into two parts, let  $\lambda \in (0, 1)$  be the share of consumers that follows the rule-of-thumb rule, while  $1 - \lambda$  the share that follows the rational rule. The total supply of labor efficiency units at any time is the sum of the labor supplied by the rational and rule-of-thumb agents:

$$L = (1 - \lambda) \int_{t-T_1^*}^t Q(t - \tau) N(1 - l_-) h_1 \epsilon(t - \tau) d\tau + \lambda \int_{t-T_2^*}^t Q(t - \tau) N(1 - l_-) h_2 \epsilon(t - \tau) d\tau. \quad (18)$$

Aggregate demand for capital at any time satisfies

$$K = (1 - \lambda) \left[ \int_{t-T_1^*}^t NQ(t - \tau) K_1 d\tau + \int_{t-T}^{t-T_1^*} NQ(t - \tau) K_2 d\tau \right] + \lambda \left[ \int_{t-T_2^*}^t NQ(t - \tau) K_3 d\tau + \int_{t-T}^{t-T_2^*} NQ(t - \tau) K_4 d\tau \right], \quad (19)$$

where  $K_1$ ,  $K_2$ ,  $K_3$  and  $K_4$  are given by (A.12), (A.13), (B.1) and (B.3), respectively.

Annual tax revenue (net of transfers),  $G$ , is given by

$$G = v_r r K(t) + (1 - \lambda) v_{w_1} w \int_{t-T_1^*}^t Q(t - \tau) N(1 - l_-) h_1 \epsilon(t - \tau) d\tau + \lambda v_{w_2} w \int_{t-T_2^*}^t Q(t - \tau) N(1 - l_-) h_2 \epsilon(t - \tau) d\tau + (1 - \lambda) v_c \int_{t-T}^t Q(t - \tau) N c_{T_1}(t; \tau) d\tau + \lambda \frac{v_c}{1 + v_c} \int_{t-T_2^*}^t Q(t - \tau) N [(1 - s)(1 - v_{w_2} - \theta) w h_2 \epsilon(t - \tau) (1 - l_-) + (1 - v_B) B(t) + \varphi_2] d\tau + \lambda \frac{v_c}{1 + v_c} \int_{t-T}^{t-T_2^*} Q(t - \tau) N [\Gamma + b(T_2^*) + (1 - v_B) B(t)] d\tau - (1 - \lambda) \int_{t-T_1^*}^t Q(t - \tau) N \varphi_1 d\tau - \lambda \int_{t-T_2^*}^t Q(t - \tau) N \varphi_2 d\tau + v_B \int_{t-T}^t Q(t - \tau) N B(t) d\tau, \quad (20)$$

where the last integral on the right-hand side of (20) is the total of bequests received by surviving agents at time  $t$ .

A pay-as-you-go Social Security system is modeled, where the benefits paid to *eligible* retirees at time  $t$  are financed by flat payroll taxes levied on the earnings of current workers, which means that the Social Security budget is balanced:

$$L\theta w = (1 - \lambda) \int_{t-T}^{t-T_1^*} Q(t - \tau) N b(T_1^*) d\tau + \lambda \int_{t-T}^{t-T_2^*} Q(t - \tau) N b(T_2^*) d\tau, \quad (21)$$

given that  $T_1^*$  and  $T_2^*$  both are greater or equal to 37. For those retirement dates we can determine  $z_0$  analytically by combining (21) with the retirement benefit rule and solving for  $z_0$ . In general, we



have

$$z_0 = \left\{ \begin{array}{l} \frac{L\theta w - \frac{(1-\lambda)z_1}{1+e^{z_2-z_3T_1^*}} \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau - \frac{\lambda x z_1}{1+e^{z_2-z_3T_2^*}} \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}{(1-\lambda) \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau + \lambda x \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* \geq 37, \text{ and } T_2^* \geq 37, \\ \frac{L\theta w - \frac{(1-\lambda)z_1}{1+e^{z_2-z_3T_1^*}} \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau}{(1-\lambda) \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* \geq 37, \text{ and } T_2^* < 37, \\ \frac{L\theta w - \frac{\lambda x z_1}{1+e^{z_2-z_3T_2^*}} \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}{\lambda x \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* < 37, \text{ and } T_2^* \geq 37, \\ \emptyset, \text{ if } T_1^* < 37, \text{ and } T_2^* < 37. \end{array} \right. \quad (22)$$

Observe that where both types of agents choose to retire prior to age 62, they will receive no benefits, and the Social Security revenues will be simply unspent. In reality, the unspent portion of the payroll revenues in the U.S. goes to the Trust Fund, but this possibility is ignored for the sake of simplicity. In all other cases (first three expressions on the right-hand side of (22)),  $z_0$  is determined endogenously and completely balances the Social Security budget. Certainly, the incentive structure should be such that the first expression for  $z_0$  prevails, which would be consistent with reality when most people retire no earlier than 62 years old.<sup>8</sup>

The size of bequests is determined by the bequest-balance equation

$$\begin{aligned} \int_{t-T}^t Q(t-\tau)B(t)d\tau &= (1-\lambda) \left[ \int_{t-T_1^*}^t m(t-\tau)Q(t-\tau)K_1d\tau + \int_{t-T}^{t-T_1^*} m(t-\tau)Q(t-\tau)K_2d\tau \right] \\ &+ \lambda \left[ \int_{t-T_2^*}^t m(t-\tau)Q(t-\tau)K_3d\tau + \int_{t-T}^{t-T_2^*} m(t-\tau)Q(t-\tau)K_4d\tau \right], \end{aligned} \quad (23)$$

where the right-hand is the total amount of capital held by agents who die at time  $t$  (note that since  $N$  is constant it has been cancelled out from both sides).

Factor prices are competitively determined and equal to

$$w = (1-\alpha)\frac{Y}{L}, \quad (24)$$

$$r = \alpha\frac{Y}{K} - \delta, \quad (25)$$

where  $\delta \in \mathbb{R}_{++}$  is the private capital depreciation rate.

<sup>8</sup>Note our pension benefit structure implies that if a person retires before he turns 62 years old, he will get nothing forever. In reality, though, he will just have to wait until he turns 62 to become eligible for some benefits. The assumption made here is not problematic, however, as in all the forthcoming computational findings people choose to retire sufficiently later than the earliest eligibility age.

**Definition 1** A Stationary Competitive Equilibrium (SCE) is characterized by: (i) consumption rules that obey (7) for rational consumers and (13) for rule-of-thumb consumers given factor prices  $r$  and  $w$ , tax rates  $v_r, v_c, v_{w_1}, v_{w_2}, v_B$ , and  $\theta$ , human capital parameters  $h_1$  and  $h_2$ , pension redistribution parameter,  $x$ , Social Security parameters  $z_0, z_1, z_2$ , and  $z_3$ , bequests,  $B(t)$ , transfer parameters  $\beta_1$  and  $\beta_2$ , and retirement dates  $T_1^*$  and  $T_2^*$ , which are determined by (8) and (16), respectively; (ii) factor prices  $w$  and  $r$  that are constant and satisfy (24) and (25), respectively, given government purchases,  $G$ , that satisfy (20), labor  $L$  that satisfies (18), capital stock  $K$  that satisfies (19) for given individual savings demand  $k(t; \tau)$  and retirement choices of both groups of agents; (iii) Social Security benefit formula  $b(T_1)$  and  $b(T_2)$  where the scale parameter  $z_0$  satisfies (21) for a given  $w$  and  $r$  and for given choices of retirement dates of both types of agents; and (iv) the bequest  $B(t)$  that satisfies (23) given individual savings demand  $k(t; \tau)$ .

### 3 Benchmark Calibration and a Welfare Measure

We start by benchmark parameterization in order to replicate some of the salient features of the U.S. economy, which we will call targets. Note that in our model there are some exogenous parameters which are readily available (e.g., payroll tax rate), and some parameters which are not so observable (e.g., discount rate). Therefore, the values of observable parameters were obtained from the available literature and we will aim not to deviate from them notably in our attempts to meet the targets. Greater slack is allowed for when it comes to adjusting unobservable or difficult-to-observe parameters.

We first set  $\theta = 10.6\%$ , which is equal to the full Old Age Survivors Insurance (OASI) tax rate in the U.S. (It is common to assume that the employer share of payroll taxes is passed on to workers in the form of lower wages). Setting consumption tax,  $v_c = 5.5\%$ , capital income tax,  $v_r = 30\%$ , and bequest tax  $v_B = 10\%$  is consistent with Mendoza et al. (1994), İmrohoroglu (1998), and De Nardi et al. (1999).

The impact of the productive public expenditures on aggregate output, captured by parameter  $\eta$ , is very difficult to pin down precisely, and there has been a wide disagreement about its magnitude since the seminal contribution by Aschauer (1989).<sup>9</sup> Nevertheless, based on the literature, it seems plausible to set  $\eta$  to 0.20, and we do likewise.

Next, the share of the rule-of-thumb consumers needs to be chosen. There has been a preponderance of macro estimates of  $\lambda$  when some consumers choose to live hand-to-mouth. Reis (2006) argues that "about one third of the U.S. population rationally chooses to never plan, live hand-to-mouth, and save very little." Since we will be classifying people into earnings-based deciles groups below, we thus choose  $\lambda = 0.30$ , close to Reis's estimate. Cohort size is normalized to  $N = 1$ .

Based on the *Current Population Survey's* estimates, the OECD reports on the U.S. gross weekly earnings deciles for full-time workers aged 16 and over (both sexes). For the 2005 sample, the mean earnings value for the first three deciles are compared with those of the upper rest of the distribution. That allows  $h_2$  to be set roughly at 0.43, while normalizing  $h_1$  to unity. Then the weekly earnings are converted to the yearly earnings and for poor households they are found to constitute roughly half of the OECD *Online Tax Benefit Calculator's* average wage for 2005 (\$37,637), and, for the rich, they constitute 1.18 of the average wage. We proceed then using the OECD calculator for 2005, where

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<sup>9</sup>See, among others, Costa et al. (1987), Munnell (1990), Lynde and Richmond (1993), Holtz-Eakin (1994), and Otto and Voss (1994).

it is assumed that only the primary earner earns income, while the secondary earner does not. A household is assumed to have two dependent children. From the calculator, we therefore compute  $\beta_1 = 0$  and  $\beta_2 = 0.32$ . Setting  $\beta_1 = 0$  is consistent with the observation made in Piketty and Saez (2007), that transfers constitute a very small fraction of middle- and high-income earners' incomes. The 2005 marginal tax rates are then applied to the rich and poor households' earnings to calculate their respective statutory tax liability, finding that  $v_{w_1} = 0.149$  and  $v_{w_2} = 0.122$ .

Greater flexibility is now allowed in setting values for other exogenous variables in trying to hit the targets, as described below.

**Target 1** A capital-output ratio,  $K/Y$ , is from 2.9 to 3.1. This is a standard range used in this line of research (see, e.g., Gourinchas and Parker, 2002; Bullard and Feigenbaum, 2007; Feigenbaum, 2008), and we will target capital-output ratio likewise.

**Target 2** A gross pre-tax safe real rate of return,  $r$ , is allowed to take a wider range (preferably close to 3.5%, but not higher than 10%). The lower boundary of this estimate is used in Gourinchas and Parker (2002), Bullard and Feigenbaum (2007), Feigenbaum (2008), and the upper boundary is the Feldstein's (1995) estimate of pre-tax rate of return on corporate capital investment.

**Target 3** The OECD reported that total tax revenue as a fraction of GDP in the U.S. was 27.3% in 2005, but those revenues incorporate many sources such as Social Security contributions (about 6.7% of GDP) and property taxes (about 3.1% of GDP). So, we will allow  $\bar{G}/Y$  to be close to, but preferably not higher than 17.5%, where  $\bar{G} \equiv G + (1 - \lambda) \int_{t-T_1^*}^t Q(t-\tau)N\varphi_1 d\tau + \lambda \int_{t-T_2^*}^t Q(t-\tau)N\varphi_2 d\tau$  is the amount of expected gross government revenues in our model.

**Target 4** According to 2009 Retirement Confidence Survey of American households, the planned retirement age is 65 years old. There are, however, a number of surprise shocks in reality, which would induce some workers to quit the workforce earlier than they originally planned. Since those surprise shocks are not modelled in the present paper, we prefer our median expected retirement age not to deviate from 65 years old significantly.

**Target 5** In the U.S., retirement benefits depend on the age at which benefits are claimed. Those who claim benefits the earliest get the smallest annuity, and the largest benefit is received by retiring later at age 70.<sup>10</sup> As for all the above targets, the ratio of benefits at 70 to benefits at 62 (i.e.,  $b(45)/b(37)$ ) is also endogenous in our model (since  $z_0$  is endogenous), and we choose the baseline parameterization such that this ratio is 1.84. This number was obtained from the *Social Security Online Benefit Calculator* for the low-income agent born in 1948 and considering retirement at either 62 or 70. The fact that a worker with a dependent wife should receive half of his primary insurance amount on the top of his own actual monthly payments is taken into account. (We deliberately target the benefit ratio for the poor, since payments to the rich would be taxed, and thus more difficult to measure).

**Target 6** Since, in reality, the aggregate consumption profile is not smooth, and at the date of retirement there is a discrete decline in aggregate life-cycle consumption, we target the decline to be

<sup>10</sup>For simplicity, we assume that the date of initiation and retirement are synchronized.

in the range of 10 to 20 percent (see Ameriks, et al., 2007, for estimates). Rational consumers do not experience any consumption drop (so, the size of their drop is zero), but rule-of-thumb consumers do (because of the low working-age saving and a low Social Security replacement ratio). After taking the weighted average of the two, the aggregate drop in our model is equal to

$$D = \lambda \frac{(1-s)(1-v_{w_2} - \theta)wh_2\epsilon(T_2^* - \tau)(1-l_-) + \varphi_2 - \Gamma - b(T_2^*)}{(1-s)(1-v_{w_2} - \theta)wh_2\epsilon(T_2^* - \tau)(1-l_-) + \varphi_2 + (1-v_B)B},$$

which is expected to be in the range of 10 to 20 percent, although the calibrated  $D$  should be close to the lower end of the range if  $s > 0$ . (We drop the time subscript from bequests for the sake of convenience since, by assumption, bequests are uniformly distributed across the lifespan). This will be our final target.

To ensure that the above targets are met under our baseline scenario, we set  $\alpha = 0.35$  and  $\delta = 0.07$ , which are close to the values used in Bullard and Feigenbaum (2007), Feigenbaum (2008), and Bucciol (2008). Macro economists have traditionally considered a wide range for  $\rho$  and we set  $\rho = 0.01$ . Further, we set  $\sigma$  (the parameter capturing the trade-off between consumption and leisure in the utility function), equal to 0.35 which is close to the value used in Heijdra and Ligthart (2006). We also set  $l_- = 0.64$  since an agent who sleeps 8 hours a day would be able to spend 16 hours every day in non-work activity (leisure). (We abstract here from all unofficial work-related, time-consuming activities and public holidays). Then someone who works 40 hours per week uses about 36% of his weekly available non-sleep time at the workplace.

Many studies investigating some forms of inattentiveness in saving, have often assumed  $s = 0$ , which is a special case of the Keynesian rule-of-thumb. There have been, however, some pilot implementations considering  $s$  values of up to 12 percent (Choi et al., 2005). To be consistent with the idea that rule-of-thumb savers save little and thus do not accumulate enough wealth, a low value for  $s$  is preferred in the benchmark, although, in principle,  $s$  can vary from 0 to 100%. We decide to set  $s = 0.01$ , which is in between the hand-to-mouth case, and  $s = 0.035$  (which was the saving rate of a mid-size U.S. manufacturing company's low-saving employees, wishing to join an accelerated saving plan, according to Thaler and Benartzi, 2004).

Recalling that the U.S. Social Security system redistributes income towards the less wealthy, from the *Social Security Online Benefit Calculator* we can see that, under our earnings assumptions, the poor receive about 62 percent of the benefits of the rich, but we set  $x$  to a higher value, 0.70, to account for the fact, that in reality, the rich pay more taxes on pension benefits (which we assumed away). As the poor earn only 43 percent of the wages of the rich, however, it is in this sense we say that the current Social Security program favours the poor.

Table 1 reports the values of some of the key exogenous and endogenous variables of our model. From Table 1 we can see that Targets 1-3 and 6 have been met (or very nearly so). The median retirement age in our model is 64.14 (since there are more rational consumers) and this is not unreasonably different from the expected age in Target 4. The benefit at age 70, divided by that at age 62 is approximately equal to 1.84, which is nearly a perfect match to Target 5. In addition, using (23) we calculate the inheritance-output ratio as close to 3 percent, which is higher (but not terribly so) than estimates existing in the literature (see Gale and Scholz, 1994, and Hendricks, 2001, for details). The level of net output,  $\bar{Y} \equiv Y - \delta K$  (output net of depreciation) under this benchmark scenario is 34.65.

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Table 1 Benchmark Parameterization and the Performance of the Model

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Production		
$\alpha$	0.35	share of private capital
$\eta$	0.20	public capital elasticity
$\rho$	0.01	discount rate
$\delta$	0.07	capital depreciation rate
$K/Y$	2.99	capital-output ratio
$r$	0.047	interest rate
Households		
$\sigma$	0.35	share of consumption in utility
$l_-$	0.64	fraction of time spent in leisure
$h_2/h_1$	0.43	poor-to-rich human capital endowment ratio
$s$	0.01	poor's saving rate
$T_1^*+25$	64.14	retirement age of the rich agent
$T_2^*+25$	65.49	retirement age of the poor agent
$D$	0.099	aggregate drop in consumption at retirement
Government		
$\theta$	0.106	Social Security payroll tax
$v_c$	0.055	consumption tax
$v_r$	0.30	capital tax
$v_{w_1}$	0.149	statutory wage tax rate on rich
$v_{w_2}$	0.122	statutory wage tax rate on poor
$v_B$	0.10	tax rate on bequests
$\beta_1$	0.00	(non-pension) benefits/earnings ratio for rich
$\beta_2$	0.32	(non-pension) benefits/earnings ratio for poor
$\overline{G}/Y$	0.175	ratio of gross tax revenues to GDP
Pension System		
$x$	0.70	poor-to-rich pension benefits ratio
$b(45)/b(37)$	1.84	age 70-to-62 Social Security benefits ratio
$z_0$	0.052	endogenous Social Security balance-budget parameter
$z_1$	0.29	exogenous Social Security benefit parameter
$z_2$	34.2	exogenous Social Security benefit parameter
$z_3$	0.92	exogenous Social Security benefit parameter

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Hence, our benchmark parameterization produces a decent replication of the U.S. economy.

### 3.1 Quantifying Welfare Gains

To quantify how the benchmark equilibrium is compared with an alternative SCE, we use *compensating variation* as the percentage change in the annual consumption of a household in the benchmark SCE that is needed to bring his lifetime utility to the same level as that attained by a household in the alternative equilibrium. We denote the compensating variation for the rich and poor as  $CV_1$  and  $CV_2$ , respectively.

To distinguish the dates of retirement under alternative SCE and avoid a cluster of notations, let  $T_1^*$  and  $T_2^*$  represent the optimal retirement dates associated with the *benchmark* SCE, and  $T_1$  and  $T_2$  would be the corresponding retirement dates under a non-benchmark SCE. It is straightforward to show that the compensating variation for the rich and the poor agents would be calculated as follows

$$\begin{aligned}
CV_1 = & \exp \left[ \left\{ \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} \ln c_{T_1}(t; \tau) dt + (1-\sigma) \int_{\tau}^{\tau+T_1} Q(t-\tau) e^{-\rho(t-\tau)} \ln l_- dt \right. \right. \\
& \left. \left. - (1-\sigma) \int_{\tau}^{\tau+T_1^*} Q(t-\tau) e^{-\rho(t-\tau)} \ln l_- dt - \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} \ln c_{T_1^*}(t; \tau) dt \right\} \right. \\
& \left. / \left( \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} dt \right) \right] - 1, \tag{26}
\end{aligned}$$

$$\begin{aligned}
CV_2 = & \exp \left[ \left\{ \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} \ln c_{T_2}(t; \tau) dt + (1-\sigma) \int_{\tau}^{\tau+T_2} Q(t-\tau) e^{-\rho(t-\tau)} \ln l_- dt \right. \right. \\
& \left. \left. - (1-\sigma) \int_{\tau}^{\tau+T_2^*} Q(t-\tau) e^{-\rho(t-\tau)} \ln l_- dt - \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} \ln c_{T_2^*}(t; \tau) dt \right\} \right. \\
& \left. / \left( \sigma \int_{\tau}^{\tau+T} Q(t-\tau) e^{-\rho(t-\tau)} dt \right) \right] - 1. \tag{27}
\end{aligned}$$

If, say,  $CV_1$  is positive, that means that deviating from a benchmark SCE, improves the welfare of the rich agent, and the same logic applies to the poor consumer. This compensating variation metric includes general-equilibrium effects, and it closely follows the welfare metric used in İmrohoroglu et al. (2003).

## 4 Financing Pensions with another Tax

This section discusses the welfare consequences of lowering payroll taxes, and refinancing Social Security with a non-payroll tax. It is important to keep in mind that there is *no* permutation in our model where a certain amount is reallocated from existing revenue to fund Social Security benefits. Consider a reduction in payroll tax leading to a decline in pension benefits, which are compensated with greater non-payroll tax revenues, so that the level of the government productive expenditures remains constant.

For the sake of argument, assume that the new value of the payroll tax is two percentage points lower than the benchmark case, i.e.,  $\theta = 8.6\%$ . The government then raises a non-payroll tax. Let the net non-payroll tax revenue collection in the benchmark scenario be  $G$ , while at the new SCE with a higher non-payroll tax it will be  $G_{new}$ , and consider the cases where  $G_{new} - G > 0$ . Assume the positive difference is used to finance pension benefits. Hence, equations (21) and (22) will be rewritten, respectively, as follows:

$$L\theta w + G_{new} - G = (1-\lambda) \int_{t-T}^{t-T_1^*} Q(t-\tau) Nb(T_1^*) d\tau + \lambda \int_{t-T}^{t-T_2^*} Q(t-\tau) Nb(T_2^*) d\tau, \tag{28}$$

and

$$z_0 = \left\{ \begin{array}{l} \frac{L\theta w + G_{new} - G - \frac{(1-\lambda)z_1}{1+e^{z_2-z_3T_1^*}} \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau - \frac{\lambda x z_1}{1+e^{z_2-z_3T_2^*}} \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}{(1-\lambda) \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau + \lambda x \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* \geq 37, \text{ and } T_2^* \geq 37, \\ \frac{L\theta w + G_{new} - G - \frac{(1-\lambda)z_1}{1+e^{z_2-z_3T_1^*}} \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau}{(1-\lambda) \int_{t-T}^{t-T_1^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* \geq 37, \text{ and } T_2^* < 37, \\ \frac{L\theta w + G_{new} - G - \frac{\lambda x z_1}{1+e^{z_2-z_3T_2^*}} \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}{\lambda x \int_{t-T}^{t-T_2^*} Q(t-\tau)Nd\tau}, \text{ if } T_1^* < 37, \text{ and } T_2^* \geq 37, \\ \emptyset, \text{ if } T_1^* < 37, \text{ and } T_2^* < 37. \end{array} \right. \quad (29)$$

The task is to ensure a non-payroll tax is raised enough that, in a resulting SCE, the aggregate benefit payment is equal to 3.019, which is the benchmark level of payroll revenues when the Social Security tax rate is 10.6%. In Table 2, some quantitative results are reported.

Consider, for instance, if consumption tax is increased to 7.455%, the generated extra non-payroll revenues would be just sufficient to bring the aggregate payroll revenues back to the original benchmark level. It can be seen that rich people are somewhat better off, while the welfare of the poor is hardly affected and people do not alter their retirement decisions much. The net output increases but very moderately so.

Table 2: Financing Social Security with a Higher Non-Payroll Tax ( $\theta = 8.6\%$ )

$v_r$	$v_c$	$v_B$	$v_{w_1}$	$v_{w_2}$	$T_1+25$	$T_2+25$	$CV_1$	$CV_2$	$\Delta G/G$	$\Delta \bar{Y}/\bar{Y}$
39.99%					64.18	65.53	-0.59%	-0.67%	10.07%	-1.15%
	7.455%				64.16	65.55	0.63%	-0.04%	9.01%	0.22%
			17.3%		64.15	65.53	-0.50%	1.42%	9.19%	-0.08%
				24.499%	64.17	65.29	2.49%	-7.34%	9.02%	0.16%
		52%			64.16	65.59	0.70%	-1.14%	9.14%	0.21%

Note:  $v_r$ —capital income tax,  $v_c$ —consumption tax,  $v_B$ —bequest tax,  $v_{w_1}$ —wage income tax on rich,  $v_{w_2}$ —wage income tax on poor,  $T_1$ —retirement date of rich,  $T_2$ —retirement date of poor,  $CV_1$ —welfare gain for rich,  $CV_2$ —welfare gain for poor, and  $\Delta G \equiv G_{new} - G$ .  $\bar{Y}$ — output net of depreciation. Empty cells imply benchmark values have been used.

It can be seen from Table 2 that it is not possible to refinance Social Security with a non-payroll tax increase, while improving the welfare of both agents at the same time, given that the payroll tax is down from the baseline 10.6 to 8.6 percent. However, in the case of the consumption tax, note that the welfare loss to the poor is practically nil, that is, higher consumption tax comes close to

being beneficial to both agents at the new steady state. Moreover, the government non-payroll tax revenues and the output net of depreciation increase by about 9.01% and 0.22% respectively.

Now, we are interested to know whether the results in Table 2 remain generally robust if more and more Social Security benefits are financed with distortive non-payroll taxes. Even if no welfare-improving refinancing of the Social Security is found, it would be interesting to analyze what rich people would prefer as opposed to the preferences of the poor. In other words, can a scenario be found where the rich would favor one form of refinancing, while the poor another? Further, is it possible that as we experiment with larger payroll tax cuts, the previously computed small welfare loss to the poor, in the case of the consumption tax increase, would become even more negative, or does it start to become positive?

To answer those questions, we present Figure 1, where the payroll tax rate is plotted on the horizontal axis, while the lifetime utility levels of the rich and the poor are reported on the vertical axis. For easier readability and comparison, a constant positive number has been added to the utility values of the poor, so that at the baseline payroll tax rate of 10.6%, the values of the utilities of the rich and the poor are the same. Going from the far right value of the payroll tax (10.6%) all the way towards the origin implies that the payroll tax rate keeps falling, and the corresponding non-payroll tax rate keeps rising, so that the aggregate level of pension benefits remains the same.

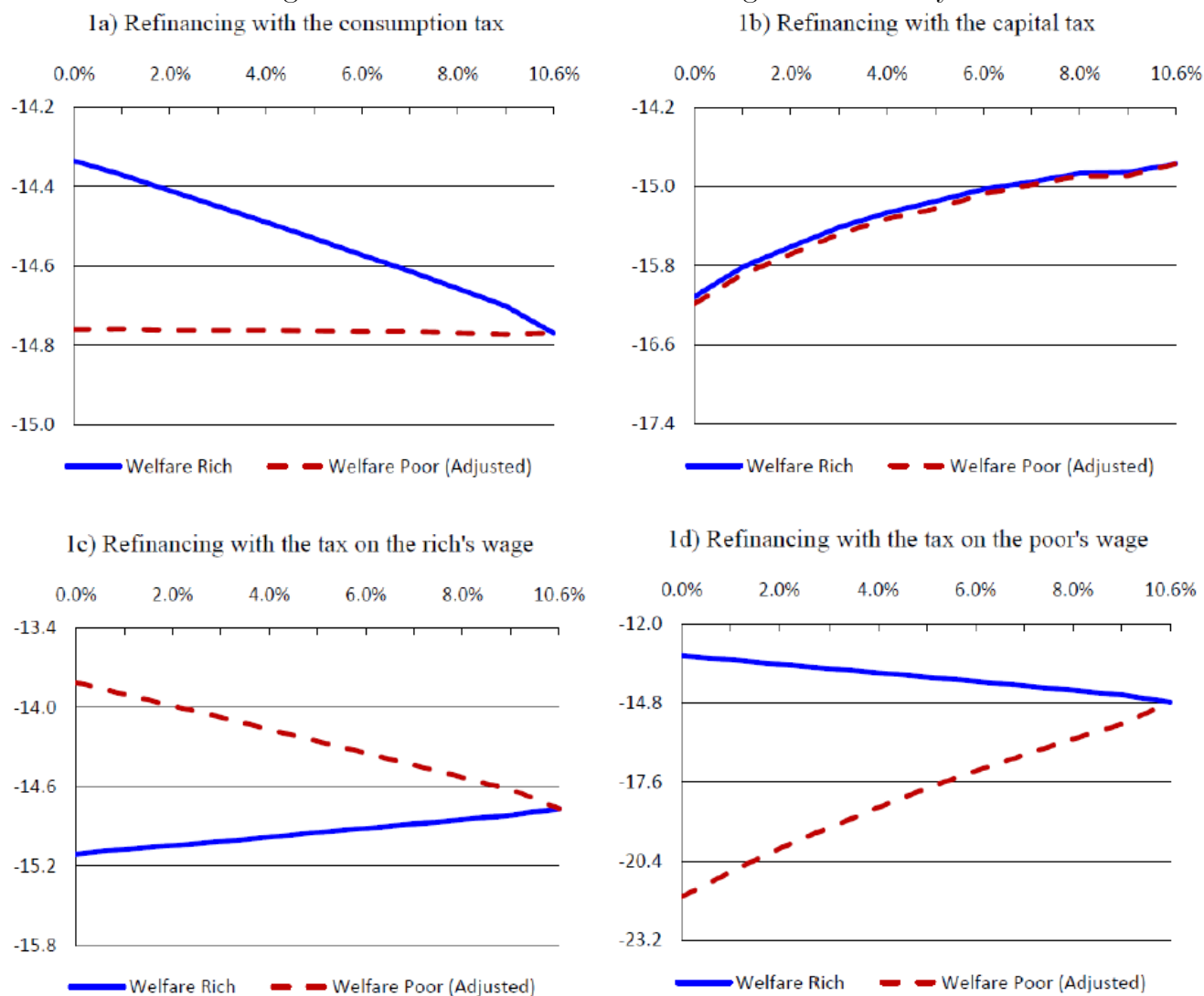
Consider first Figures 1c and 1d. It can be seen that the rich always gain when the payroll tax rate is cut, while pension benefits are financed by placing a tax burden on the wage earnings of the poor. Similarly, the poor would prefer if their richer brethren's wage earnings to be taxed more heavily to compensate for a given reduction in the payroll tax. Further, as the poor comprise a minority of the population and their earnings are low, a proportionally higher tax on their wage income would need to be imposed to compensate for a given reduction in pension benefits. That is, the well-being of the poor would deteriorate rapidly should they be targeted as the main source of Social Security refinancing.

Figure 1b shows that both the poor and the rich become strictly worse-off as the new capital income tax revenues are transferred to finance a given shortfall in pension benefits. Both the rich and the poor would be likely to oppose refinancing with capital tax revenues since they would become equally worse-off. The negative effect of capital taxation has long been pointed out in many authoritative studies, and in our model high taxes on capital reduce capital accumulation and wages. For instance, when the payroll tax is down to 9 percent, raising the capital tax rate by over 8 percentage points to balance Social Security requirements would cause the total capital stock,  $K$ , and the wage,  $w$ , to decrease by about 5 and 1.9 percent, respectively.

The most interesting case is presented in Figure 1a. It can be seen that, overall, there is a very small change in the welfare of poor people once bigger revenues from consumption tax are used to finance Social Security. However, it can be seen that when payroll tax is totally eliminated, there is still a rise in the welfare of the poor (more precisely,  $CV_2$  is equal to 0.07%), but it is the rich who would gain the most:  $CV_1 = 3.36\%$ . Higher consumption tax stimulates growth and improves factor prices. Not surprisingly, total GDP and wages would be higher by 2.08 and 2.45 percent, respectively, when the payroll tax rate is totally abolished and the benefits are refinanced with higher tax on consumption. The aggregate capital stock would rise by 6.49 percent. There could also be some concerns about the positive role of the consumption tax on capital accumulation in an economy with a sizable minority of chronically low-saving individuals. This study shows, however, once the general-equilibrium effects are allowed for in a heterogeneous economy with endogenous retirement, the growth-stimulating effect of higher consumption taxes can, indeed, be easily achieved.

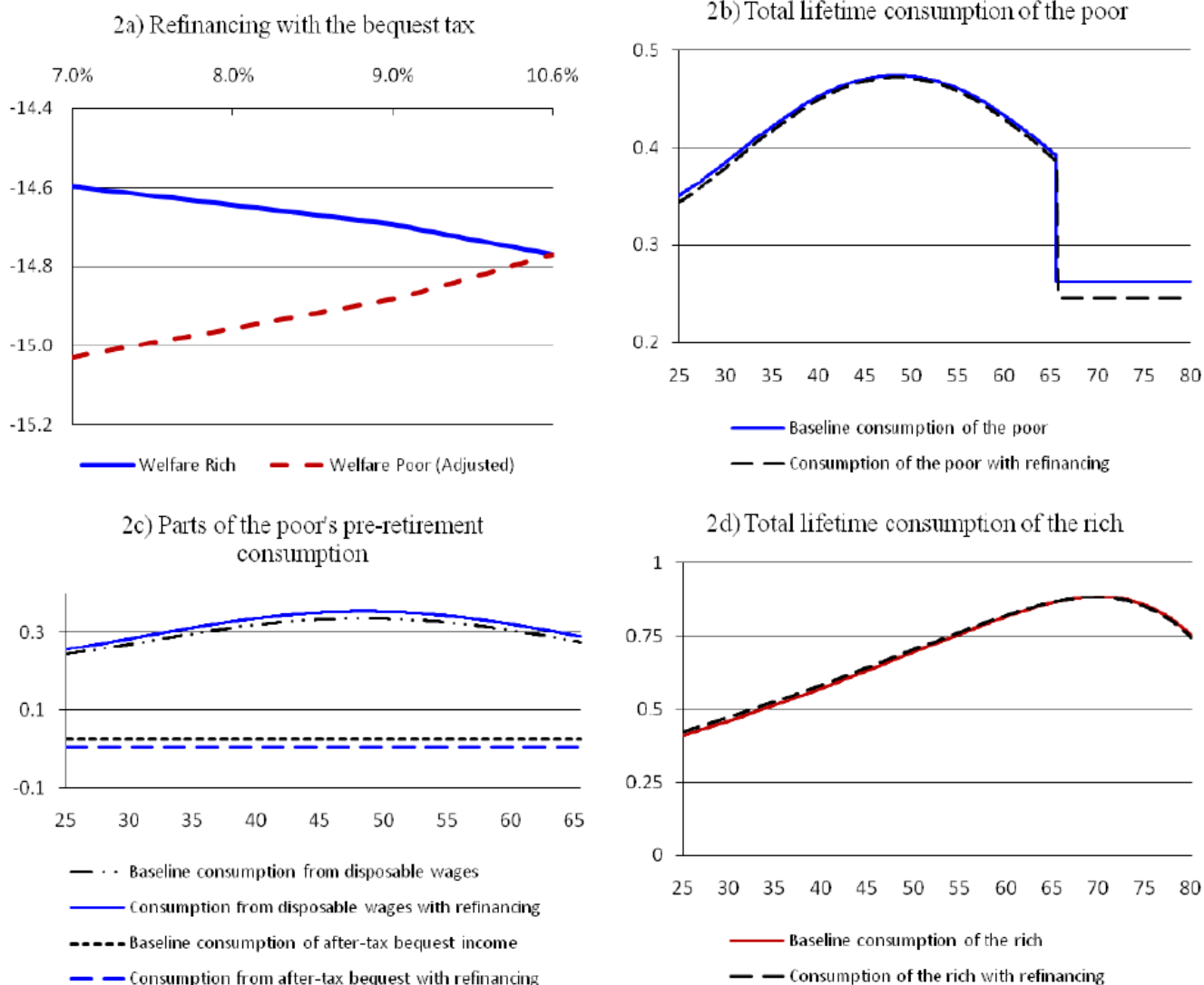


Figure 1: Welfare Effects of Refinancing Social Security



Now consider what would happen when a higher bequest tax is used to refinance pension benefits. Because of the small amount of bequests inherited at any given time, only a small percentage point reduction in payroll tax can be covered by a very high tax rate on bequests. The rich would gain from refinancing, while the poor would be strictly worse-off. This is shown below in Figure 2a. The intuition can be understood by looking at the consumption profiles of the rich and the poor agents, as depicted in the diagrams. In Figures 2b and 2d the lifetime consumption profiles of the poor and the rich agents, respectively, are depicted when the payroll tax rate is cut from the baseline 10.6 to 7 percent, and the tax on bequests is raised to approximately 84 percent to cancel out the shortfall in aggregate Social Security benefits. Note what happens to the consumption by the poor. From Figure 2b it is clear that, during working life of the poor, their consumption is lower when Social Security is refinanced by means of a bequest tax. This is due to the fact that the poor do not experience a large increase in not-so-high wage earnings when the payroll tax is lowered, while they do have to pay higher bequest taxes.

Figure 2: The Effects of Bequest Tax Refinancing ( $\theta = 7\%$ ).



In Figure 2c, the lower two straight lines depict after-tax bequest consumption,  $(1 - v_B)B(t)$ , with and without refinancing; the two upper curves are simply after-tax consumption from wages. Due to a decline in  $\theta$ , the agent's after-tax consumption from wages shifts upward, but the shift is slightly less than the downward shift in  $(1 - v_B)B(t)$ . Given that due to refinancing, the general-equilibrium wage rate,  $w$ , does not increase much and  $\varphi_2$  part of the poor's consumption (not depicted) does not increase very much, the overall, pre-retirement consumption goes down slightly. When it is needed most, that is, during the retirement phase, when the poor rely on their very low private savings and the same amount of pension benefits as in the baseline scenario, the heavily-taxed bequests cause the retirement consumption to drop much more significantly (see Figure 2b).

Figure 2d shows the lifetime consumption paths of the rich with or without alternative financing of Social Security benefits. For the rich consumer, already high wage earnings rise by a greater margin when the payroll tax is cut. Given that the rich have been spreading out their bequest consumption over the entire life-cycle, a much higher bequest tax is not capable of pushing consumption down at

any point. For the relatively earlier phase of their lifetime, the new consumption path of the rich is slightly higher, and they get to live and enjoy consumption with greater probability. Note also that both the rich and the poor choose to push their retirement date forward, but very slightly so, meaning that the negative welfare effect of consuming less leisure is small.

Compare these results with those depicted in Figures 3a and 3b, where the consumption paths of the rich and the poor, respectively, have been presented with the consumption tax refinancing and zero payroll tax. The pre-retirement consumption of the poor is higher, but during the retirement phase, where payroll taxes would not be paid anyway, consumption drops, partly because consumption is taxed more heavily. So, whether the rule-of-thumb agent would be better off is a quantitative question. The same is technically true for the rich, whose lifetime consumption is shown in Figure 3b. The early consumption of the rich (up to about age 56) is everywhere higher, but during this period the agent is more likely to be alive and to enjoy consuming. Despite the fact that after the age of 56 his lifetime consumption is lower, the overall effect on welfare is positive.

Figure 3: The Effects of Consumption Tax Refinancing ( $\theta = 0\%$ ).



The analysis in this section implies that getting rid of payroll taxes and relying on higher consumption taxes to finance Social Security would improve welfare, factor prices, aggregate saving and the total GDP. We also calculate that both the rich and the poor would delay their retirement dates by approximately 1.68 and 4.44 months, respectively.

## 5 Conclusion

The hegemony of payroll taxes in supplying funds to the U.S. Social Security program has been preserved throughout U.S. history, despite the lack of strong economic counter-arguments against the use of alternative forms of taxes to fund pay-as-you-go pension benefits. This study attempted to answer the following question: If one can tax a single economic activity in order to fund a given amount of pay-as-you-go benefits, what should that activity be?

Within a calibrated general equilibrium model with heterogeneous behaviors, uncertain lifetime, income heterogeneity, endogenous saving, retirement, tax-transfer schemes and productive government spending, it has been found that totally abolishing payroll taxes and raising consumption tax to restore Social Security's balance, increases the steady-state welfare of the majority, without affecting the welfare of the minority. Factor prices improve and people even voluntarily choose to retire later in life.

One caveat regarding our study is that we have not been able to look at the transitional dynamics, which would be a challenging task given the type of model considered in the study. Finer income heterogeneity across the households, and an alternative way of modelling low-saving behavior (other than assuming a simple rule-of-thumb behavior) would be a worthy extension to pursue as well.

## Appendix A

The Hamiltonians for the problem (1)-(6) for a given  $T_1$  are

$$\begin{aligned} H_1(k(t; \tau), p_1(t), c(t; \tau), t) \equiv & H_1 = Q(t - \tau)e^{-\rho(t-\tau)}[\sigma \ln c(t; \tau) + (1 - \sigma) \ln l_-] + \\ & + p_1(t) [(1 - v_r)rk(t; \tau) + (1 - v_{w_1} - \theta)wh_1\epsilon(t - \tau)(1 - l_-) \\ & + \varphi_1 - (1 + v_c)c(t; \tau) + (1 - v_B)B(t)], \end{aligned} \quad (\text{A.1})$$

and

$$\begin{aligned} H_2(k(t; \tau), p_2(t), c(t; \tau), t) \equiv & H_2 = \sigma Q(t - \tau)e^{-\rho(t-\tau)} \ln c(t; \tau) \\ & + p_2(t)[(1 - v_r)rk(t; \tau) - (1 + v_c)c(t; \tau) \\ & + (1 - v_B)B(t) + b(T_1)], \end{aligned} \quad (\text{A.2})$$

respectively, where  $p_1(t)$  and  $p_2(t)$  are the adjoint functions.

The necessary conditions are

$$\frac{\partial H_1}{\partial c(t; \tau)} = \sigma Q(t - \tau)e^{-\rho(t-\tau)} \frac{1}{c(t; \tau)} - (1 + v_c)p_1(t) = 0, \quad (\text{A.3})$$

$$\frac{\partial H_2}{\partial c(t; \tau)} = \sigma Q(t - \tau)e^{-\rho(t-\tau)} \frac{1}{c(t; \tau)} - (1 + v_c)p_2(t) = 0, \quad (\text{A.4})$$

$$\frac{\partial H_1}{\partial k(t; \tau)} = p_1(t)(1 - v_r)r = -\frac{dp_1(t)}{dt}, \quad (\text{A.5})$$

$$\frac{\partial H_2}{\partial k(t; \tau)} = p_2(t)(1 - v_r)r = -\frac{dp_2(t)}{dt}, \quad (\text{A.6})$$

$$\begin{aligned} \frac{\partial H_1}{\partial p_1(t)} &= (1 - v_r)rk(t; \tau) + (1 - v_{w_1} - \theta)wh_1\epsilon(t - \tau)(1 - l_-) \\ &+ \varphi_1 - (1 + v_c)c(t; \tau) + (1 - v_B)B(t) = \frac{dk(t; \tau)}{dt}, \end{aligned} \quad (\text{A.7})$$

$$\frac{\partial H_2}{\partial p_2(t)} = (1 - v_r)rk(t; \tau) - (1 + v_c)c(t; \tau) + (1 - v_B)B(t) + b(T_1) = \frac{dk(t; \tau)}{dt}, \quad (\text{A.8})$$

$$p_1(\tau + T_1) = p_2(\tau + T_1). \quad (\text{A.9})$$

Expressions (A.5), (A.6) and (A.9) imply that  $p_1(t) = p_2(t) = p(t)$ , and

$$p(t) = e^{-r(1-v_r)t}\Omega, \quad (\text{A.10})$$

where  $\Omega \in \mathbb{R}$ .

From (A.3), (A.4) and (A.10) it follows that

$$c(t; \tau) = \frac{\sigma Q(t - \tau)}{\Omega(1 + v_c)e^{(\rho-r(1-v_r))t-\rho\tau}}. \quad (\text{A.11})$$

Substituting (A.11) into (A.7) and using (4), we have

$$k(t; \tau) = \left\{ \int_{\tau}^t [(1 - v_{w_1} - \theta)wh_1\epsilon(u - \tau)(1 - l_-) + \varphi_1 - \frac{\sigma Q(u - \tau)}{\Omega e^{(\rho - r(1 - v_r))u - \rho\tau}} + (1 - v_B)B(u)]e^{-(1 - v_r)ru} du \right\} e^{r(1 - v_r)t}, \quad (\text{A.12})$$

where  $u$  is a dummy variable of integration.

Substituting (A.11) into (A.8) and using (5), we have

$$k(t; \tau) = \left\{ \int_t^{\tau + T} \left[ \frac{\sigma Q(u - \tau)}{\Omega e^{(\rho - r(1 - v_r))u - \rho\tau}} - (1 - v_B)B(u) - b(T_1) \right] e^{-(1 - v_r)ru} du \right\} e^{r(1 - v_r)t}. \quad (\text{A.13})$$

Evaluating (A.13) and (A.12) at  $\tau + T_1$  and setting them equal to each other, we find that

$$\Omega = \frac{\sigma \int_{\tau}^{\tau + T} \frac{Q(t - \tau)}{e^{\rho(t - \tau)}} dt}{\int_{\tau + T_1}^{\tau + T} b(T_1)e^{-(1 - v_r)rt} dt + \int_{\tau}^{\tau + T} (1 - v_B)B(t)e^{-(1 - v_r)rt} dt + q}, \quad (\text{A.14})$$

where

$$q \equiv \int_{\tau}^{\tau + T_1} [(1 - v_{w_1} - \theta)wh_1\epsilon(t - \tau)(1 - l_-) + \varphi_1]e^{-(1 - v_r)rt} dt. \quad (\text{A.15})$$

All remains is to use (A.14) in (A.11) to confirm (7).

## Appendix B

Using initial condition (11), a particular solution to (9) for  $t \in [\tau, \tau + T_2]$  is

$$k(t; \tau) = \left\{ \int_{\tau}^t [s(1 - v_{w_2} - \theta)wh_2\epsilon(u - \tau)(1 - l_-)]e^{-(1 - v_r)ru} du \right\} e^{r(1 - v_r)t}, \quad (\text{B.1})$$

which implies

$$k(\tau + T_2; \tau) = \int_{\tau}^{\tau + T_2} [s(1 - v_{w_2} - \theta)wh_2\epsilon(t - \tau)(1 - l_-)]e^{(1 - v_r)r(\tau + T_2 - t)} dt. \quad (\text{B.2})$$

Under the end-point condition (12), we get a particular solution to (9) for  $t \in (\tau + T_2, \tau + T]$  as

$$k(t; \tau) = \frac{\Gamma}{(1 - v_r)r} [1 - e^{(1 - v_r)r(t - \tau - T)}]. \quad (\text{B.3})$$

From (B.3) it clearly follows that

$$k(\tau + T_2; \tau) = \frac{\Gamma}{(1 - v_r)r} [1 - e^{(1 - v_r)r(T_2 - T)}]. \quad (\text{B.4})$$

Setting (B.4) equal to (B.2), results in

$$\Gamma = \frac{s(1 - v_{w_2} - \theta)(1 - v_r)(1 - l_-) rwh_2 \int_{\tau}^{\tau+T_2} \epsilon(t - \tau) e^{(1-v_r)r(\tau+T_2-t)} dt}{1 - e^{(1-v_r)r(T_2-T)}}. \quad (\text{B.5})$$

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