Social Security: Universal vs Earnings-Dependent Benefits

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Abstract

In this paper, I compare the welfare implications of implementing Bismarckian and Beveridgean social security systems.

I first judge a social security system with universal benefits against one with earnings-dependent benefits that provides the same level of benefits. Surprisingly, I find that agents can be better off with the implementation of a system with universal benefits both in the short and in the long-run.

I then allow agents to choose the replacement rates in a democratic process and find that future agents and the current young are worse off when benefits are earnings-dependent than when they are universal.

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Keywords: social security, universal benefits, earnings-dependent benefits, voting, welfare.

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1 Introduction

Social security systems are generally financed on a pay-as-you-go basis with taxes levied on the labor income of workers financing the benefits to retirees. These benefits are typically of two types: in a Beveridgean social security system benefits are universal, in the sense that all retirees from the same cohort are entitled to the same level of benefits; in a Bismarckian system retirees’ benefits depend on their earnings history.

The two systems have distinct redistributional features and (in)efficiency implications. In a Beveridgean system retirees receive the same level of benefits independently of their earnings history. This implies some intragenerational redistribution from high to low income earners, as high earners contribute significantly more than low earners and receive the same benefits. In opposition, a Bismarckian system where benefits are proportional to earnings does not imply any direct intragenerational redistribution. Moreover, by making benefits dependent on earnings a Bismarckian system can reduce the distortionary effect of social security taxation on the supply of labor. This lays ground to the common perception that, on average, agents are better off with a social security system with earnings-dependent benefits, a Bismarckian system, than with one with universal benefits, a Beveridgean system. In fact, in their seminal work, and, to my knowledge, the only work that presents a welfare comparison of the two systems, Auerbach and Kotlikoff (1987) find efficiency gains from establishing a link between an agent’s contributions and benefits in a standard overlapping generations model calibrated to match the U.S. economy.

In this paper, I study the welfare implications of Bismarckian social security systems and Beveridgean social security systems firstly when the parameters of the system are given and then when agents choose the corresponding policy parameters.

I evaluate social security systems using an overlapping generations economy where a large number of agents are “born” each period and live for a maximum of four periods. The population in this economy grows at a constant rate and individuals supply labor endogenously for the first three periods of their lives and retire during the last period before dying. With a pay-as-you-go social security system, the government levies a tax on labor income and uses the revenue to fund the benefits of the retirees. I let benefits either be proportional to the economy’s labor income, in a Beveridgean system, or proportional to the recipient’s lifetime earnings, in a Bismarckian system. I quantify the findings by calibrating the parameters of the economy and solving numerically for
the equilibrium paths for the economy under different social security systems.

I first compare a social security system with universal benefits to one with earnings-dependent benefits that provides the same level of benefits. Surprisingly, although I abstract from the intragenerational distributional features of the systems, I find that the current young and future generations are better off in the economy with universal benefits. When benefits are earnings-dependent the link between agents’ contributions and benefits they receive upon retirement implies that the tax distortion is lower for any given level of social security benefits. However, the reduction in the tax distortion implies a much lower decrease in labor supply with the introduction of social security. There is also a higher decrease in savings, and, hence, in the accumulation of physical capital, with an earnings-dependent system. In general equilibrium, the disparity in the impact on the supply of labor and on capital accumulation implies that net wages are significantly lower and, therefore, agents are worse off with an earnings-dependent system than with a comparable universal system.

As I increase the exogenous social security tax rate, the reduction in tax distortions achieved through earnings-dependency increases exponentially, and ends up offsetting the other effects, leading to welfare gains of the system with earnings dependent benefits relatively to a comparable system with universal benefits.

I then construct a political economy model of social security, where agents vote for the parameters that determine the level of social security benefits, to study the welfare implications of implementing either a Bismarckian or a Beveridgean social security system. I find that, when voters choose social security benefits, the median voter prefers a significantly larger social security system when benefits are earnings-dependent. As in Cooley and Soares (1999), the general equilibrium effects are determinant. An earnings-dependent benefits system generates a higher supply of labor and lower accumulation of capital along the equilibrium path than a comparable universal benefits system. While the impact on the initial period factor prices is very similar across systems, thereafter the interest rate increases and the wage rate decreases significantly more with an earnings-dependent benefits system. The augmented impact on the interest rate generates the extra support for social security by the older agents, that have accumulated capital, and the median voter is enticed to vote for a bigger social security system when she is choosing over levels of earnings-dependent benefits. As a result agents are worse off, in the short-run and in the long-run, when benefits are earnings-dependent than when they are universal.
There is an extensive literature that studies the introduction of social security in the context of majority voting in general equilibrium overlapping generations models. Previous work on the political economy of social security has focused on explaining the size of social security systems, looking at the determination of the level of benefits which, in general, have been assumed to be universal (see Browning (1975), Boadway and Wildasin (1989), Cooley and Soares (1999), Tabellini (2000) and Boldrin and Rustichini (2000) among others). Zhang and Zhang (2003) study the optimality of earnings-dependent benefits in an endogenous fertility model where they have a positive impact on human capital accumulation and growth. Cremer and Pestieau (1998) and Conde-Ruiz and Profeta (2007) focus on the composition of the social security system; their objective is not to compare the welfare implications of the two systems but to generate an equilibrium where both systems coexist.

Koethenbuerger et al. (2008), develop an analytical political economic model, where voters choose the size of the social security system given the exogenous composition of the benefits and show that as the relative size of the earnings-dependent component increases, the size of the system increases. This paper is different from theirs in many dimensions. In the first place, Koethenbuerger et al (2008) do not pursue a welfare analysis of the different social security systems. Moreover, in sharp contrast with the results of this paper, as they do not allow factor prices to change, they find that earnings-dependent benefits systems are more attractive for the median voter because of lower distortion in labor supply and less intragenerational redistribution.

This paper is organized as follows. Section 2 introduces the economic environment. Section 3 presents the economic equilibria, describes the political decision process and the resulting politico-economic equilibria. Section 4 calibrates the model while section 5 presents the findings. Section 6 concludes.

2 The Economic Environment

I study an economy where, in each period, a large number of heterogeneous agents with a maximum lifetime of four periods are born. The population size in period $t$ is given by $N_t$ and grows at the rate $n$. The share of age $i$ individuals in the population, given by the measure $\mu_i$, $i = 1, ..., 4$ is constant over time and $\mu_{i+1} = \frac{1}{1+n} \mu_i$, with $\sum_{i=1}^{4} \mu_i = 1$.

Agents in each generation maximize their discounted lifetime utility: for an agent born in period
the lifetime utility is given by

$$
\sum_{i=1}^{4} \beta^{i-1} U(c_{i,t+i-1}, l_{i,t+i-1})
$$

(1)

where $\beta$ is the discount factor, $c_{i,t+i-1}$ is consumption and $l_{i,t+i-1}$ is leisure of an age $i$ individual in period $t + i - 1$.

The “momentary” utility function is assumed to take the constant relative risk aversion form of a Cobb-Douglas consumption-leisure index,

$$
U(c, l) = \frac{c^{\sigma} l^{1-\sigma}}{1-\rho},
$$

(2)

where $\rho$ is the inverse of the intertemporal elasticity of substitution, and $\sigma$ is the coefficient of consumption on the Cobb-Douglas index.

The budget constraint facing an individual of age $i$ can be written as

$$
a_{i+1,t+1} = (1 + r_t) a_{i,t} + y_{i,t} - c_{i,t},
$$

(3)

where $y_{i,t}$ is the real net labor income plus social security transfers of an age $i$ individual, $a_{i,t}$ denotes the asset holdings of an age $i$ individual at the beginning of the period $t$ and $r_t$ denotes the rate of return on these assets.

I assume that agents may work the first three periods of their lives, but must retire afterwards. Before their mandatory retirement, age $i$ workers supply endogenously $h_i$ hours of labor and have different productivity levels represented by $\varepsilon_i$, an efficiency index that quantifies the productivity of an hour of work supplied by an agent of age $i$. After retirement, workers receive social security benefits, $b_t$. The level of benefits can either be proportional to the average labor income of the retiree, in a Beveridgean system, or independent of her past earnings and proportional to the income of agents currently employed, in a Bismarckian system.

$$
b_{4,t} = \begin{cases} 
\theta_t e_{4,t}, & \text{in a Bismarckian system,} \\
\phi_t \bar{w} \varepsilon_t, & \text{in a Beveridgean system.}
\end{cases}
$$

(4)
where
\[ e_{i,t} = \frac{\sum_{i=1}^{i-1} w_{t-i+1} h_{t-i+1} \varepsilon_t}{3} \]  
(5)
is the average lifetime earnings of an age-i retiree at time t and \( \overline{w\varepsilon_t} \) is the weighted average earnings of the working generations.

Under these assumptions, the net labor income of an individual is given by
\[ y_{i,t} = \begin{cases} 
(1 - \tau_{ss,t}) w_{t} h_{i,t} \varepsilon_i, & \text{for } i = 1, 2, 3, \\
 b_{i,t}, & \text{for } i = 4. 
\end{cases} \]  
(6)
where \( \tau_{ss,t} \) is the social security tax rate on labor income.

The production technology of the economy is described by a constant-returns-to-scale function,
\[ Y_t = F(K_t, L_t) = K_t^{1-\alpha} (L_t(1 + g)^{1})^\alpha, \]  
(7)
where \( \alpha \in (0, 1) \) is the labor share of output, \( Y_t \), and \( K_t \) and \( L_t \) are the capital and labor inputs. I allow for exogenous growth in labor productivity at a constant rate \( g \). The capital stock is equal to the aggregate asset holdings of agents in the economy. It depreciates at a constant rate \( \delta \) and evolves according to the law of motion,
\[ K_{t+1} = (1 - \delta) K_t + I_t. \]  
(8)

There is a government in this economy that implements the pay-as-you-go social insurance system. The government must impose taxes on labor income so that its budget is balanced each period.
\[ \tau_{ss,t} w_t L_t = N_t \mu_4 b_{4,t} \]  
(9)

3 Equilibrium

I first describe the individual economic problem faced by agents for a given sequence of political parameters. I then describe how these parameters are determined and define a politico-economic equilibrium for this economy.
3.1 Economic Decisions

Given a sequence of social security replacement rates and the corresponding tax rate, the economic problem of an age \( i \) individual is to choose a sequence of consumption, leisure and asset holdings that maximize the discounted lifetime utility subject to her budget constraints. Define \( X \) and \( x_i \) as vectors describing respectively the aggregate state of the economy and the individual state of an agent. \( X = (A, E) \), where \( A \) and \( E \) represent the distributions of assets and of past lifetime earnings across agents. \( x_i = (a_i, e_i) \), where \( a_i \) and \( e_i \) represent the level of assets and average labor earnings of an age-\( i \) agent. I write this as:

\[
V_i(x_i, X; \Theta) = \max_{c_i, l_i, a'_{i+1}, e'_{i+1}} \{U(c_i, l_i) + \beta V_{i+1}(x'_{i}; X'; \Theta)\}
\]

s.t.

\[
a'_{i+1} = (1 + r)a_i + y_i - c_i,
\]

\[
y_i = \begin{cases} 
(1 - \tau_{ss})w_i\epsilon_i, & \text{for } i = 1, 2, 3, \\
b_i, & \text{for } i = 4.
\end{cases}
\]

\[
e'_{i+1} = e_i + \frac{wh_i\epsilon_i}{3},
\]

\[
l_i + h_i = 1,
\]

\[
X' = P(X; \Theta),
\]

\[
V_5 = 0,
\]

given \( \Theta \).

Here, \( P(X; \Theta) \) is the law of motion of the distribution of capital and lifetime earnings. \( \Theta \) is a given sequence of replacement rates that describe the social security policy in each period from the current period on, \( \Theta = \{\theta_t, \phi_t\}_{t=1}^{\infty} \).

This problem generates a set of decision functions \( c_i(x_i, X; \Theta), h_i(x_i, X; \Theta), a_i(x_i, X; \Theta) \), a law
of motion $P(X; \Theta)$, and value functions $V_i(x_i, X; \Theta)$.

In this economy, competitive firms maximize profits taking the wage rate and interest rate as given. The first-order conditions for the firm's problem determine the following functions for the net real return to capital and the real wage rate:

$$r = (1 - \alpha) \left( \frac{K}{L(1 + g)} \right)^{-\alpha} - \delta,$$

$$w = \alpha(1 + g)^t \left( \frac{K}{L(1 + g)^t} \right)^{1-\alpha}. \quad (11)$$

### 3.2 Political Decisions

In the political economy model of social security, I implement either a Bismarckian or a Beveridgean social security system in an initial period. The corresponding replacement rate, $\theta$ or $\phi$, is chosen by the agents through a democratic voting process and it determines the level of social security benefits as described by equation (4). As in Cooley and Soares (1999), I restrict the set of possible sequences of policy functions to be sequences of a constant policy parameter. Therefore agents in the implementation period choose a social security system described by this constant parameter.

To show how social security could be implemented and sustained by rational forward looking agents Cooley and Soares (1999) introduced a reputational mechanism. The reputational mechanism is represented by a trigger-strategy where the reversion to the equilibrium without social security is used as a threat. If the workers today vote against paying social security benefits, then agents next period lose confidence in the sustainability of the system. This loss of credibility means the cost of defecting today involves the collapse of the system tomorrow.

Let $\Theta^*$ be a rule that specifies the social security system. The assumed expectations mechanism is,

$$\Theta^*_{t+l} = \begin{cases} 
\Theta^*, & \text{if } \Theta_t = \Theta^* \\
0, & \text{otherwise} 
\end{cases} \quad \forall \ L > l > 0. \quad (12)$$

If the social security benefits this period are the ones expected, agents expect the “majority” to perform according to the specified rule for period $t + l \ \forall \ L > l > 0$. The maintenance of the social security replacement rate can be viewed as a reward to retirees for not having deviated from the equilibrium when they were tax paying workers. If $L > 3$, then, if the current generations of
workers fail to go along, they will not be rewarded in the future. The system can be re-instated after $L$ periods and it is possible to choose an $L$ such that the punishment strategy is renegotiation proof.

To abbreviate the analysis and focus on the choice of the social security parameters, I assume that a social security system that is chosen and implemented in an initial period with the reputational mechanism described by (12) is sustained henceforth.

3.2.1 The political choice

In the initial period, agents choose the policy parameters that will be implemented, $\Theta = \theta$ or $\Theta = \phi$.

The solution to the agents political problem involves evaluating the utility obtained under all possible values for the policy parameter. This requires that the agents predict the competitive equilibrium path from the implementation period on for all alternative choices.

The political problem of the age-$i$ agent in the period when social security is implemented is:

$$\max_{\Theta} V_i(x_{i,0}, X_0; \Theta)$$

where $X_0$ and $x_{i,0}$ describe, respectively, the aggregate state of the economy and the individual state of age-$i$ agent in the implementation period.

In this setting, if the preferences over the possible parameters are single-peaked, there exists a policy function, defined by the choice of the median voter, that resists every set of proposals to change, and thus constitutes a voting equilibrium.

**Lemma 1:** Let $m$ be the age of the median voter in the initial period of the voting process, then the aggregate choice will be determined according to:

$$\Theta(X_0) = \arg \max_{\Theta} V_m(x_{m,0}, X_0, \Theta).$$

### 3.3 Equilibrium

**Definition:** A *politico-economic equilibrium* is a set of value functions, $V_i(x, X; \Theta)$, decision rules for consumption, individual labor supply and asset holding $c_i(x, X; \Theta)$, $h_i(x, X; \Theta)$, $a_i(x, X; \Theta)$, $\forall i$, $\forall X$, $\forall \Theta$. 


a law of motion for the distribution of capital and lifetime earnings $P(X; \Theta)$, a sequence of relative factor price functions \( \{W(X; \Theta), R(X; \Theta)\} \), functions for the level of capital $K(X; \Theta)$ and for the effective labor supply $L(X; \Theta)$ and a political outcome function $\Theta(X)$ such that these functions satisfy:

1. The individual’s dynamic program (10).

2. The first-order conditions of the firm’s problem (11).

3. Factor markets clear:

\[
K = K(X; \Theta) = N_t \sum_{i=1}^{4} \mu_i \alpha_i + 1,
\]

\[
L = L(X; \Theta) = N_t \sum_{i=1}^{3} \mu_i \theta_i(x, X; \Theta) x_i.
\]

4. The commodity market clears:

\[
N_t \sum_{i=1}^{4} \mu_i [c_i(x, X; \Theta) + a_i(x, X; \Theta)] = F(K, L) + (1 - \delta)K.
\]

5. The law of motion for the distribution of capital and earnings is generated by the decision rules of agents:

\[
P(X; \Theta) = \left[ a_i(x, X; \Theta) e_i + \frac{w_i(x, X; \Theta) x_i}{3} \right]_i.
\]

6. The political outcome function is generated by the aggregation of the choices of agents following lemma 1.

7. The government budget is balanced.

4 Calibration

To solve this model numerically, I calibrate the parameters of the model so that the politico-economic steady-state equilibrium of the economy with universal benefits matches some long run features of the U.S. economy. I assume that a period in the model corresponds to 15 years. Agents
in this model are assumed to be born at the age of 21 when they become full-time workers, working 3 periods (45 years) and then retiring for the last period of their lives (15 years).

Population Growth Rate:

I match the annual population growth rate for the model to the average population growth rate in the US economy in the last decades, 0.0124 (Citibase Data, 1946-1993). For the four generation model this translates to a growth rate of \( n = 0.203 \).

Preferences

I choose the coefficient of risk aversion \( \rho \) and the value for the discount factor, \( \beta \), so that the equilibrium annual interest rate is approximately 6% and the equilibrium social security tax rate is about 9.4% (see Halter and Hemming, 1987)\(^1\). I calibrate the coefficient of consumption in the utility function, \( \sigma \), to 0.322 so that on average agents in the labor force allocate around 31% of their time to market activities.

Technology

Following Cooley and Prescott (1995), the share of labor in the production function is set to be 0.6 and I set the depreciation rate so that the steady-state annual investment/capital ratio for this economy is 0.076. Finally, I set the exogenous growth rate to be 1.34% per year.

Labor efficiency units:

The age specific endowments of efficiency units for the economies with heterogeneous agents are taken from Hansen (1993).

The parameter choices are summarized in the following table:

<table>
<thead>
<tr>
<th>Table 1 - Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
</tr>
<tr>
<td>0.946</td>
</tr>
</tbody>
</table>

\(^1\)Note that in a UB system \( \phi_t = \frac{\nu_t}{1-\mu_t} \times \tau_t \).
5 Findings

I first compare a social security system with universal benefits to one with earnings-dependent benefits while keeping the level of social security benefits constant across systems. I start by maintaining factor prices fixed and focus on the partial equilibrium differences between the systems. I then let prices adjust and study the contrast between the systems when the general equilibrium effects are allowed to play a role.

Finally, I compute the politico-economic equilibria where agents vote for the replacement rate given one system or the other, and compare the welfare implications of implementing either a universal benefits or an earnings-dependent benefits social security system.

5.1 Economic Equilibria

In this section I evaluate the welfare impacts of introducing comparable social security systems with either earnings-dependent benefits or universal benefits.

I set the replacement rate of the social security system with universal benefits (hereafter referred to as the UB system) so that it delivers a tax rate of 9.4%, and choose the sequence of replacement rates for the system with earnings-dependent benefits (hereafter referred to as the EDB system) such that social security benefits are the same as with the UB system along the equilibrium path.²

In order to abstract from all pecuniary effects of social security, I first look at the partial equilibrium effect of the implementation of social security. For this purpose, I set the wage and interest rate to their equilibrium levels in the steady-state of the economy without social security. I then take into account the pecuniary effect of social security by studying the general equilibrium where factor prices are endogenous.

5.1.1 Partial Equilibria

In the EDB system, the level of benefits is proportional to an agent’s lifetime labor income and workers account for the impact of an increase in their labor income in their social security benefits.

²While there are many alternative criteria to compare social security systems, I chose to compare systems that provide the same level of benefits because an earnings-dependent benefit system is perceived as more efficient. This implies that it can provide the same level of benefits at a lower cost, therefore generating lower welfare losses, than an universal benefits system.
The optimality condition for the labor supply decision is then:

\[ h_{i,t} : u_l(c_{i,t}, l_{i,t}) = w_t \varepsilon_i \left[ (1 - \tau_t) + x_{i,t} \right] u_c(c_{i,t}, l_{i,t}) \]  

(18)

where

\[ x_{i,t} = \sum_{l=3+1}^{4} \frac{\theta_{t+l-i}}{3} \prod_{n=1}^{l-i} \frac{1}{1 + r_{t+n}} \]  

(19)

is the impact of current labor supply on retirement benefits in terms of current units of consumption.

This link between benefits and earnings reduces the effective level of social security taxation. For the same wage rate and social security tax rate, the relative cost of leisure in terms of consumption is higher because of the impact of labor income on social security benefits. Hence agents increase consumption, and decrease leisure. This results in an increase in the supply of labor relatively to the UB case. Moreover, because of the increase in labor supply the tax needed to finance the same level of benefits is lower in the EDB system which further decreases the tax distortion. As can be seen in figure (1 panel e), a lower social security tax rate is needed to finance the same level of social security benefits when benefits are earnings-dependent. In figure (1 panel d) it is clear that the supply of labor is less negatively affected by social security when benefits are earnings-dependent. Notice also that, when benefits are earnings-dependent, we observe a long-run increase in the aggregate supply of labor relatively to the equilibrium without social security.

To some extent savings decreases by more in the earnings-dependent case (see figure 1 panel c). The impact of an increase in labor on social security benefits, \( x_{i,t} \), is higher as agents get closer to their retirement. Therefore, the reduction in the effective level of social security taxation and the corresponding raise in the cost of opportunity of leisure augment with an individual’s age. Hence, the increase of the supply of labor relatively to the UB case rises with age (see figure 2 panels a-c) and so does the increase in after tax labor income. As a result, the lifetime income profile becomes steeper and young and middle-age agents reduce their savings to smooth their lifetime consumption profiles (see figure 2 panels d and e). Notice however that there is an increase in retirees’ assets (see figure 2 panel f). In order to smooth the consumption-leisure bundle, and although their leisure automatically goes up upon retirement, retirees want to consume more than in the UB system because their lifetime resources are higher. The resulting increase in retirees’ asset accumulation is smaller than the decrease in younger agents’ savings and the EDB system has a higher negative
impact on savings than the UB system.

More importantly, not only the present value of net benefits and the after-tax wage rate are higher under the EDB system because of the decrease in the tax rate, but the reduction in the tax distortion reduces the corresponding deadweight loss. Consequently, the welfare of current and future young increases (see figure 1 panel a).

I measure the welfare benefit of an agent in a given equilibrium relatively to a reference equilibrium as the fixed percentage increase in the lifetime consumption of the individual needed to equate the level of welfare she would achieve in the reference equilibrium. I refer to this measure as the compensating variation. The compensating variation is positive (negative) if there is a welfare loss (gain) relatively to the reference equilibrium.

We would have to decrease the lifetime consumption of a young agent at the time of implementation of the EDB system by 0.14% for her to be as well off as with the implementation of the UB system. To make a young agent as well off in the steady-state of the economy with the EDB system as in the steady-state of the economy with the UB system, we would have to decrease her lifetime consumption by 0.15%. As a reference note that for the initial young to be as well off with the implementation of the UB system as in the steady-state without social security we would need to increase her consumption by 2.84%.

5.1.2 General Equilibria

I now compare the impact of implementing the different types of social security systems, choosing the respective replacement rates so that the social security benefits are the same in general equilibrium.

The difference between the general equilibrium and the partial equilibrium paths stems from the adjustment of factor prices and its feedback into agents’ decisions. As we observed in the partial equilibrium analysis, the supply of labor is significantly higher when benefits are earnings-dependent and the impact of social security on savings is slightly more negative with the EDB system. As a result of its impact on savings, the EDB system results in slightly lower levels of capital (see figure 3 panel a). Once we allow factor prices to respond, the decrease in capital and increase in labor supply (see figure 3 panel b) relatively to the UB equilibrium results in a decrease in wages (see figure 3 panel c). Even though the tax rate is lower with the EDB system (see figure
3 panel e), the response of the wage rate implies a lower after tax wage rate (see figure 3 panel f). While the present value of net social security benefits is higher with the EDB system, the difference is almost negligible and the decrease in after-tax wages makes the current young and future agents worse off with the EDB system than with the UB system (see figure 5 panel a).

In this case, we would have to increase the lifetime consumption of a young agent at the time of implementation of the EDB system by 0.16% for her to be as well off as with the implementation of the UB system. To make a young agent as well off in the steady-state of the economy with the EDB system as in the steady-state of the economy with the UB system, we would have to increase her lifetime consumption by 0.27%. As a reference note that the for the initial young to be as well off with the implementation of the UB system as in the steady-state without social security we would need to increase her lifetime consumption by 2.04%, while relatively to the long-run the compensation would be 4.76%. Although, these welfare costs of adopting an EDB system instead of an UB system are small they correspond to a relevant share, about 7.8% and 5.7%, of the cost of adopting an UB social security system and they are bigger than the welfare gains obtained in partial equilibrium. This indicates that the welfare losses due to the general equilibrium effects of the EDB system are about twice the size of the gains associated with the reduction in tax distortions.

Furthermore, while the impact on after-tax wages is more negative with EDB, the impact on the rate of return is more positive (see figure 3 panel d). Consequently, in the short-run, agents that have accumulated a significant amount of assets benefit more from an EDB system. In fact, while young agents are worse off with the EDB system because of the higher decrease in after-tax wages it generates, we can see in figure (5) that all remaining initial generations are better off with the EDB system (this will be crucial when we endogenize the size of the systems). Notice also that in the initial period age-2 and age-3 agents are better off with the EDB system even though the present value of benefits net of contributions are negative and inferior to the ones obtained with the UB system (see figure 4). In contrast, age-1 agents are worse off with the EDB system although the present value of net benefits are superior to the ones obtained with the UB system.

So, relatively to an UB system, the EDB system reduces the distortionary effect of social security taxation, but it can also increase the negative impact that social security has on wage rates. In the benchmark economy, the latter effect is present and is stronger than the first; consequently the EDB system makes current young and future agents worse off than with the comparable UB
As we increase the social security tax rate, its distortionary effect increases exponentially and gains a relatively higher importance in the comparison between the two systems. For the benchmark calibration, current young and future agents are worse off with an UB system corresponding to a tax superior to 25% than with the comparable EDB system. Therefore, a considerable tax rate is necessary for the EDB system to generate a reduction in the tax distortion large enough to offset its general equilibrium effects.

5.2 Politico-economic Equilibria

In this section, I study the welfare impact of implementing a social security system when agents choose the corresponding replacement rate given that benefits are either earnings-dependent or universal.

I start by showing that voters’ preferences over the policy parameters are single-peaked. I then locate the median voter and determine the equilibrium levels of the replacement rates.

In Figure 6, we can see the lifetime utility of the agents alive in the period when social security is implemented over the policy parameters \( \theta \) (EDB) and \( \phi \) (UB). In this economy, preferences are clearly single peaked over the policy parameters. Older agents prefer higher levels of the replacement rate and the utilities of the two oldest generations are strictly increasing over the depicted levels of the replacement rates. On the other hand, younger agents prefer that no social security system be implemented and their utility is strictly decreasing with the replacement rates. Hence, the median voter is an age-2 agent which has interior peaks for the policy parameters.

The equilibrium levels of the policy parameters are those that maximize the lifetime utility of the median voter: \( \theta^* = 0.9288 \) and \( \phi^* = 0.4136 \). In steady-state these replacement rates correspond respectively to a tax rate on labor income of \( \tau^* = 0.1324 \) and \( \tau^* = 0.0942 \). Therefore an economy

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3 In the only other work, to my knowledge, that presents a welfare comparison of the two systems, Auerbach and Kotlikoff (1987) find efficiency gains from establishing a link between an agent’s contributions and benefits in a standard overlapping generations model calibrated to match the U.S. economy. In their model, the level of capital is higher in the long-run under the EB system and outweighs the effect of the increase in labor supply on wages. Their 60 overlapping generations model is a finer representation of the demographic structure of the economy, but the experiments are not similar. Auerbach and Kotlikoff (1987) compare systems where the present value of the flow of benefits paid over 15 retirement periods is a fixed percentage of the average lifetime labor income, while I compare systems that deliver the same level of benefits. More importantly, the point of this section is to show, in a realistic economic environment, that the welfare impact of linking benefits to earnings might not be positive as it is commonly perceived. The choice of a simpler generational structure is made to reduce the burden of computing the politico-economic equilibrium, the main focus of the paper.
with an EDB social security system has a higher contribution rate than one with an UB system which fits the empirical pattern observed (see Koethenbuerger et al (2008)).

Figure 7 shows the levels of several variables for the equilibrium paths with the chosen replacement rates \((\theta = \theta^*, \phi = 0\) and \(\phi = \phi^*, \theta = 0\)).

We observe that tax rates are significantly higher in a social security system with EDB than in one with UB (see figure 7 panel e); when voters choose social security benefits, the median voter prefers a significantly larger social security system when benefits are earnings-dependent. Additionally, while both systems decrease welfare, current young and future agents are worse off in the equilibrium with EDB (see figure 7 panel f).

As we saw in section 5.1.2, although the present value of net benefits for the median voter is lower with an earnings-dependent system than with a comparable UB system, its general equilibrium effects are more favorable to the median voter and older agents. The EDB system generates a higher supply of labor and lower accumulation of capital along the equilibrium path than a comparable UB system. Because of the response of the labor supply, in the initial period the wage rate increases by slightly less in the EDB system. Thereafter the interest rate increases and the wage rate decreases considerably more in the EDB equilibrium. The augmented impact on the interest rate generates an increased support for social security by agents that have accumulated capital, and the median voter is enticed to vote for a bigger social security system when she is choosing over levels of earnings-dependent benefits.

Moreover, in an universal system the social security benefits the median voter will receive upon retirement are linked to the future supply of labor, which decreases with the replacement rate, while in the EDB system, her benefits are proportional to her lifetime earnings, which are much less responsive to changes in the replacement rate. This effect increases the incentive to choose higher replacement rates in the latter case.

Finally, as we saw in the previous section, an EDB system can lead to higher welfare losses than a comparable UB system for the initial young and all future generations. As the median voter chooses a relatively bigger EDB system, these agents are much worse off with an EDB system when we allow the size of the systems to be chosen in a democratic voting process. We would have

\footnote{Koethenbuerger et al (2008) find a similar relation between the size of the system and the type of benefits, however their results hinge on an ‘efficiency-redistribution’ trade-off in an environment with intragenerational inequality where factor prices are unchangeable.}
to increase the lifetime consumption of a young agent at the time of implementation of the EDB system by 1.58% for her to be as well off as with the implementation of the UB system. To make a young agent as well off in the steady-state of the economy with the EDB system as in the steady-state of the economy with the UB system, we would have to increase her lifetime consumption by 2.65%. So once we endogenize the size of the social security system, the welfare cost of opting for an EDB system is very significant. Remember that the welfare cost for the young of an UB system relatively to the steady-state without social security is 2.04% in the short-run and 4.76% in the long-run.

In figure 6 it is clear that the three oldest initial generations are better off in the politico-equilibrium achieved with an EDB system \((\theta = \theta^*, \phi = 0)\), than in the equilibrium achieved with an UB system \((\phi = \phi^*, \theta = 0)\). So, if we allowed for the choice of systems before agents would vote on the corresponding parameters, an EDB system would be chosen over an UB system.

### 5.3 Sensitivity Analysis

In this section, I perform some sensitivity analysis with respect to the main parameters in the economic environment. Table 2 shows the sensitivity of the welfare measures and of the equilibrium levels of the replacement and tax rates to variations in the discount factor, intertemporal elasticity of substitution, coefficient of consumption in the utility function, labor’s share, the population growth rate, and the rate of technological progress. In these experiments, I raise the values of the corresponding parameters maintaining all other parameters constant, that is I do not re-calibrate the remaining parameters using the procedure described in section 4.

As can be seen in Table 2, for the purpose of the welfare comparison, there are no significant variations in the results when we alter the parameters of the model with the exception occurring when the labor share of output is modified.

When we increase the parameter \(\alpha\) to 0.7, the welfare impact of opting for an EDB system instead of a comparable UB system is relatively small. The welfare losses due to the general equilibrium effects of the EDB system are just slightly larger than the gains associated with the reduction in distortions. In this case, the capital stock is slightly higher along the EDB equilibrium path which partially offsets the increase in labor supply and contains the decrease in the after-tax wage rate.
Furthermore, while the equilibrium tax rates are larger in the politico-economic equilibrium, the difference between the steady-state tax rates obtained under an EDB system and the ones obtained under an UB system are relatively small. As a consequence, while in the short-run the welfare measure is similar to the ones obtained in the other cases, it does not increase much in the long-run.

For the other parameters, the evaluation of comparable systems delivers about the same outcome as in the other cases. With respect to the politico-economic equilibrium results the welfare loss from having EDB benefits instead of UB benefits seems to increase more than proportionally with the size of the social security systems, as expected.
# Table 2 - Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>$\beta = 0.98$</th>
<th>$\rho = 3$</th>
<th>$\sigma = 0.4$</th>
<th>$\alpha = 0.7$</th>
<th>$n = 0.3459$</th>
<th>$g = 0.3459$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparable systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensating variation</td>
<td>Short-run</td>
<td>−0.14%</td>
<td>−0.14%</td>
<td>−0.14%</td>
<td>−0.17%</td>
<td>−0.14%</td>
<td>−0.14%</td>
</tr>
<tr>
<td>in partial equilibrium</td>
<td>Long-run</td>
<td>−0.15%</td>
<td>−0.15%</td>
<td>−0.14%</td>
<td>−0.18%</td>
<td>−0.13%</td>
<td>−0.15%</td>
</tr>
<tr>
<td>Compensating variation</td>
<td>Short-run</td>
<td>0.16%</td>
<td>0.16%</td>
<td>0.17%</td>
<td>0.22%</td>
<td>0.05%</td>
<td>0.16%</td>
</tr>
<tr>
<td>in general equilibrium</td>
<td>Long-run</td>
<td>0.27%</td>
<td>0.26%</td>
<td>0.31%</td>
<td>0.39%</td>
<td>0.07%</td>
<td>0.37%</td>
</tr>
<tr>
<td><strong>Political-economic equilibria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta^*$</td>
<td></td>
<td>0.9288</td>
<td>1.0829</td>
<td>0.6256</td>
<td>0.4946</td>
<td>1.0847</td>
<td>1.8649</td>
</tr>
<tr>
<td>$\tau_{ss}(\theta^*)$</td>
<td></td>
<td>0.1324</td>
<td>0.1537</td>
<td>0.0899</td>
<td>0.0723</td>
<td>0.1593</td>
<td>0.1947</td>
</tr>
<tr>
<td>$\phi^*$</td>
<td></td>
<td>0.4136</td>
<td>0.4876</td>
<td>0.2667</td>
<td>0.2151</td>
<td>0.6042</td>
<td>0.7761</td>
</tr>
<tr>
<td>$\tau_{ss}(\phi^*)$</td>
<td></td>
<td>0.094</td>
<td>0.111</td>
<td>0.0607</td>
<td>0.049</td>
<td>0.1376</td>
<td>0.1387</td>
</tr>
<tr>
<td>Compensating variation</td>
<td>Short-run</td>
<td>1.58%</td>
<td>1.83%</td>
<td>1.1%</td>
<td>1.19%</td>
<td>1.14%</td>
<td>2.8%</td>
</tr>
<tr>
<td>$\phi = \phi^* \text{ vs } \theta = \theta^*$</td>
<td>Short-run</td>
<td>2.65%</td>
<td>2.96%</td>
<td>2.07%</td>
<td>2.31%</td>
<td>1.26%</td>
<td>4.42%</td>
</tr>
</tbody>
</table>
6 Concluding Remarks

A pure earnings-dependent benefits system is commonly perceived as being welfare improving relatively to an universal benefits system because it reduces the distortions inherent to a tax on labor income and the corresponding deadweight losses. In this paper, I find that the current young and future generations can be better off in an economy with an universal benefits system than in an economy with a comparable earnings-dependent benefits system. The earnings-dependent benefit system generates a much lower decrease in labor supply and a somewhat higher decrease in savings. In general equilibrium, the disparity in the impact on the supply of labor and on capital accumulation implies that net wages can be significantly lower and, therefore, agents can be worse off with an earnings-dependent system than with a comparable universal system.

Additionally, if we allow agents to choose social security benefits in a majority voting process, the median voter prefers a significantly larger social security system when benefits are earnings-dependent. Consequently, agents are considerably worse off, in the short-run and in the long-run, when benefits are earnings-dependent than when they are universal. As in Cooley and Soares (1999), the general equilibrium effects are determinant. An earnings-dependent benefits system generates a higher supply of labor and lower accumulation of capital along the equilibrium path than a comparable universal benefits system. The consequent bigger impact on interest rates increases the support for social security by the median voter who benefits from the increase in future labor income.

This paper does not take into account many features that might affect the results. In particular, I do not allow for intragenerational heterogeneity. Instead, I build a standard overlapping generations environment that underscores the positive features of earnings-dependent benefits systems, and therefore predisposes the model to deliver results favorable to this system relatively to a comparable universal benefits system. However, when social security parameters are chosen in a democratic process, the introduction of intragenerational heterogeneity might reinforce or weaken the negative effects of earnings-dependent benefits depending on the properties of intragenerational inequality.

Despite these limitations, this paper stresses the importance of considering the general equilibrium effects and specially the politico-economic equilibrium impact of introducing changes to the structure of the social security system.
References


A Graphs

Figure 1: Variables along partial equilibrium path for comparable social security systems
Figure 2: Labor supply and assets along partial equilibrium path for comparable social security systems
Figure 3: Variables along general equilibrium path for comparable social security systems
Figure 4: Present value of net benefits along general equilibrium path for comparable social security systems
Figure 5: Lifetime utilities along general equilibrium path for comparable social security systems
Figure 6: Lifetime utilities of period 1 agents for different values of the replacement rates
Figure 7: Variables along equilibrium path for equilibrium values of the replacement rates
B Solution Algorithm

This appendix describes the procedure used to compute the equilibria described in the paper.

The procedure involves solving for the competitive equilibrium path for a given level of the policy parameters.

I then evaluate how agents fare under different sequences of the policy parameters and then find the level of the policy parameter that maximizes the utility of the first period median voter.

B.1 The Competitive Equilibrium Path

The equilibrium paths are computed using the following algorithm:

1. I start by computing the initial state of the economy \((A_0, E_0)\).

2. I then set the set of replacement rates, \(\Theta\), which will remain constant along the equilibrium path.

3. I make an initial guess for the equilibrium path for the state of the economy and for the labor supply \(\{A, E, L\}^0\). Given this path, the levels of all the remaining endogenous variables along the path can be determined, including aggregate capital stock, \(\{K\}^0\), aggregate labor supply, factor prices, social security benefits, taxes, and \(x_{it}\) (see equation 19).

4. I can then use the optimality conditions for problem (10) to calculate the decisions of the agents along the path, \(c_i, l_i, a_{i+1}^t, e_{i+1}^t\).

5. Once we get to the individual decisions along the path, we can compute the implied path for state of the economy and for the labor supply \(\{A, E, L\}^1\).

6. Finally, we compare the corresponding path for the aggregate capital stock, \(\{K\}^1\) to the one obtained from the initial guess, \(\{K\}^0\).

7. If the new path is significantly different from the initial path we update the initial guess in step 3 and repeat these steps. Otherwise, an equilibrium path has been found.
B.2 The Implemented Social Security Tax Rate

We know describe how we use this procedure to determine the level of the replacement rate that will be implemented in the initial period.

1. I start by computing the initial state of the economy \((A_0, E_0)\).

   - I define a grid for the replacement rate that is being voted on.

   - Then, I compute the competitive equilibrium path \(\{A, E, L\}\) corresponding to each replacement rate (see the previous section of the Appendix).

   - I obtain the lifetime utility levels of the agents living in the initial period for each level of the replacement rate: \(V_i(x_i, X; \Theta)\)

   - I check for single-peakedness of preferences and locate the median voter.

2. Once the median voter is located I search for the level of the replacement rate that maximizes her lifetime utility, around the peak found in the initial grid.

   - Notice that in order to do this, I need to compute the competitive equilibrium path for each level of the replacement rate.