March 2, 2004
Preliminary draft

The Development of Public Transfers in the US: Historical Generational Accounts for Education, Social Security, and Medicare

Antoine Bommier
Université de Toulouse (GREMACQ)
and Centre National de la Recherche Scientifique
Antoine.Bommier@univ-tlse1.fr

Ronald Lee
Demography and Economics
University of California
2232 Piedmont Ave.
Berkeley, CA 94720
rlee@demog.berkeley.edu

Timothy Miller
Demography
University of California
2232 Piedmont Ave.
Berkeley, CA 94720
tmiller@demog.berkeley.edu

Stéphane Zuber
École normale supérieure, Paris
Stephane.Zuber@ens.fr

Paper prepared for the PAA annual meetings in Boston, April 1-3 2004. Research for this paper was funded by a grant from NIA, R37-AG11761. We thank Wenlan Qian for carrying out empirical estimates. David Cutler generously provided us with the data and spread sheets for his generational accounts of Medicare.

Introduction

Virtually all industrial nations have instituted public sector program to provide public education, health care (at least for the elderly), and pay as you go pensions on a nearly universal basis. Many Third World nations are following their example. The fiscal pressures to which public pensions and health care will give rise as populations age in the 21st century are well known. For the most part, nations have left programs in place that are seriously fiscally unbalanced and demonstrably unsustainable, but clamor for reform grows louder each year, while the public strongly resists any reduction in benefits.

It is pensions and health care which have drawn most attention and research, but their relation to the third major age targeted program, public education, is often ignored. In the US, Education is currently the largest public transfer program at 4.5% of GNP, followed by OASI (pensions and survivor's benefits) at 3.7% and Medicare at 2.1%. Owing mainly to the aging of the baby boomers, by 2050 the largest system will be Social Security (at 6.5%), followed by Medicare (at 4.9%), and public education (with little change at 4.8%).

For some reason, we tend to think of the pension and health benefits we receive in old age as a kind of return earned on an investment - that is, on our earlier taxes or "contributions" to these systems. When it comes to education, however, we think of it cross-sectionally, not as a benefit we receive early in life and then pay for later through our school taxes. All three programs can be viewed either as horizontally redistributive within a calendar year, or as longitudinally redistributive over the life cycle. The benefits of public education are received on average about thirty years earlier than the average age of paying taxes, which is in turn about thirty years earlier than the average age of receiving old age benefits. Each 30 years of discounting at 3% introduces a discount factor of .4, so a dollar of education received as a child carries a relatively great weight in the longitudinal accounts, 2.5 times greater than the taxes paid for education later in life, and six times greater than a dollar of benefits received in old age.

We can view these three US programs in a longitudinal context by estimating the present value at birth of survival-weighted benefits received minus taxes paid over the life cycle, for each generation. We will present such estimates in this paper for generations born from 1850 to 2090. The calculation of these net present values (NPVs) or generational accounts, as they are sometimes called, requires data covering a generation until it has completely died out, which takes about 110 years under current mortality conditions. Thus we have full accounts only for generations born 1850 to 1900 or so. By means of projections under particular assumptions about productivity growth, demographic change, and policy choices, we can continue the accounts over many more generations, past and future.

The purpose of these calculations is partly descriptive, to trace the evolution of public transfers in the US, and describe how this evolution affected different cohorts. But going beyond simple description, these estimates gain interest from a vigorous theoretical debate in the economics literature.

Many economic studies argue that a world with smaller upward transfers would be preferable. However, it is also well known that the transition from large upward transfers to smaller ones would be costly for some generations. In other words, it seems that we are left with the choice between damaging the welfare of the present and the next few future generations (if we reduce the scale of upward transfers) or damaging the welfare of an infinity of generations in the more distant future (by maintaining a high level of upward transfers). Many different positions have been taken in the face of this dilemma. Some would prefer a radical and rapid reform, while others would prefer a minimal reform that makes public transfers sustainable. But why do we face such a cruel choice? Is it because some generations in the past got a free lunch and that now we must pay for it (or to transmit the debt to future generations)? Or is it the result of a well thought-out public policy developed by our forebearers?

The first explanation undoubtedly has many supporters. But the seminal paper by Becker and Murphy (1988) provides an argument to defend the second position: the development of the social security system would have allowed the development of education, and therefore economic growth. Do we suffer now from the policy of our greedy ancestors, or should we thank them because of their globally judicious choices? This paper aims at giving some insights on this topic by looking at theoretical argument and data on public transfers in the past.

The theoretical part of the paper makes use of a simple model that is close to that of Kaganovich and Zilcha (1999). We show that the "greedy ancestors" conclusion is the only possible one if we forget to account for the development of transfers for public education (proposition 1). However, had somebody looked at the education transfers without looking at upward transfers, the opposite conclusion (of "generous ancestors") would have been found (proposition 2). When looking at downward and upward transfers separately it is therefore very easy to identify who are the winners and the losers. The interesting point made by Becker and Murphy is that, because of endogenous economic growth, this is not a zero sum game. Actually, by combining these two kinds of transfers it is possible to improve the welfare of everybody (proposition 3).

But in reality, were there in fact losers? or were there only winners ? The question is impossible to answer without having a complete understanding of the determinants of economic growth. A partial answer can, however, be given by looking at generational accounts. In particular, in a Pareto improving transition the generational account has to be positive for the first generations affected by the introduction of the public transfers.

The next section establishes some new theorems pertaining to these theoretical points.

1 Theory

Using a simple model, we show three theorems about the impact of changes in generational transfers on the welfare of successive generations. We assume a stable population with constant mortality and fertility. Actually, there have been dramatic changes in both fertility and mortality in the US. Our model only shows the "pure" effect that can be expected from changes in the policies, neglecting demographic effects, such as the US "baby boom".

1.1 Notation and assumptions

We consider an economy with both upward and downward transfers. We use a three age group model, with people studying in the first period, working in the second period and retiring in the last one.

In the remainder of this text, subscripts will denote current time when there is only one subscript. When we refer to a generation, the subscript denotes the time of "birth" of the generation, namely the time t of their first period of life. Nevertheless, we sometimes need to refer to a specific age group. In this case, the first subscript denotes the age group (1 for the young, 2 for middle-aged people, 3 for the elderly), and the second, current time.

At time t, the total population is $N_t = N_{1t} + N_{2t} + N_{3t}$, where N_{1t} is the number of the young, N_{2t} the number of middle-aged people and N_{3t} the number of the elderly. We assume that the population is growing at an exogenous constant rate n, that is $N_{1t} = n \times N_{1,t-1}$. Furthermore, in each generation, people have a probability $1-p$ to die at the end of the first and of the second period (they are all dead after the third). Therefore, they have a probability p to live during the second period, and a probability p^2 to live during the third period. This means that $N_{2,t+1} = p \times N_{1,t}$ and $N_{3,t+2} = p^2 \times N_{1,t}$.

To simplify the analysis, we will also assume that the interest rate is constant ($r_t = r \; \forall t$, $r > 1$) and independent of the private saving and borrowing (we may be in a small open economy with the interest being fixed on international markets, although this assumption would not apply to the US).

We consider two exogenous systems of public transfers in the economy. One is a downward transfer system flowing from middle aged people toward the young: public educational expenditure. It is funded by a tax on the income of the middle aged. The average tax payment for education is $\epsilon_t y_t$, where ϵ_t the tax rate for education at time t and y_t the average earnings per middle-aged person at time t. The average benefit from the educational policy is therefore $(\frac{p}{n})\epsilon_t y_t$. The factor $\frac{p}{n}$ accounts for population difference between the first and the second generation, as $\forall t \; \frac{N_{2t}}{N_{1t}} = \frac{p}{n}$.

The second public transfer is an upward one. Old aged person are provided with a pension income, by income taxation of the middle aged at rate ρ_t. The average contribution to the public pension policy is $\rho_t y_t$, and the average benefit is $b_t = (\frac{n}{p})\rho_t y_t$.

In the first period, people receive an education which produces their human capital endowment, h_t[1]. We suppose that the aggregate amount of human capital provided to a generation, H_t, depends only on aggregate public educational spendings, E_t, and on the human capital of the previous generation: $H_t = H(E_t, H_{t-1})$. We assume that the aggregate production function of human capital is Cobb-Douglas:

$$H(E_t, H_{t-1}) = E_t^{\alpha} \times H_{t-1}^{1-\alpha} \tag{1}$$

Where $1 > \alpha > 0$.

[1] h_t is the average human capital per capita.

Aggregate public spending on education is funded through a payroll tax on middle-aged people: $E_t = N_{2t} \times \epsilon_t y_t$. And the aggregate human capital of people from generation $t-1$ at time t is $H_{t-1} = N_{2t} \times h_{t-1}$. Therefore, the per capita human capital endowment for people of the generation born in t is:

$$h_t = \frac{H_t}{N_{1t}} = \frac{N_{2t}}{N_{1t}} \times (\epsilon_t y_t)^\alpha \times (h_{t-1})^{1-\alpha} = \frac{p}{n} \times (\epsilon_t y_t)^\alpha \times (h_{t-1})^{1-\alpha} \tag{2}$$

We also assume that individuals (or their parents for them) can borrow s_{1t} at rate r. But the only way to accumulate human capital is through public education, so that private spending has no impact on the amount of human capital. Borrowing only lets people allocate there wealth across their life-cycle.

In the second period, people work. In per capita terms, they earn y_{t+1}. They can also save money $(s_{2,t+1})$ for the next period but they must repay their borrowing of the first period with an interest rs_{1t}, and they have to pay taxes proportional to their income.

Finally, in the last period, people receive the interest from their savings of the second period $(rs_{2,t+1})$ and a pension transfer, $b_{t+2} = \frac{p}{n}\rho_{t+2}y_{t+2}$.

The evaluation function for each generation is the expected utility of a representative individual. The expected utility of an individual with consumption $(c_{1t}, c_{2,t+1}, c_{3,t+2})$ is assumed to be given by:

$$U_t(c_{1t}, c_{2,t+1}, c_{3,t+2}) = \sum_{i=1}^{i=3} p^{(i-1)} u(c_{i,t+i-1}) \tag{3}$$

with $u(c) = \frac{u^\nu}{\nu}$. Thus there is no pure time preference, and agents have a constant relative risk aversion.

The program for the representative individual of generation t is the following:

$$\max_{c_{1t}, c_{2,t+1}, c_{3,t+2}} \left[u(c_{1t}) + pu(c_{2,t+1}) + p^2 u(c_{3,t+2})\right] \tag{4}$$

$$s.t.\ c_{1t} + \frac{p}{r}c_{2,t+1} + \left(\frac{p}{r}\right)^2 c_{3,t+2} = \frac{p}{n}\epsilon_t y_t + \frac{p}{r}(1-\epsilon_{t+1}-\rho_{t+1})y_{t+1} + \left(\frac{p}{r}\right)^2 \times \frac{n}{p}\rho_{t+2}y_{t+2} \tag{5}$$

where equation (5) is the survival-weighted intertemporal budget constraint, assuming that intertemporal markets are perfect.

Denote $Y_t = \frac{p}{r} y_{t+1}$, the present value at birth of lifetime labor income for generation t.

We introduce two important economic aggregates. First, we define NT_t^e, the net transfer wealth received through public education by generation t. It is the survival weighted, discounted sum of the transfers received for its education minus the taxes paid to finance the education system. In our framework: $NT_t^e = (\frac{p}{n}\epsilon_t y_{1t} - \frac{p}{r}\epsilon_{t+1} y_{t+1})$. Secondly, we define NT_t^p, the net transfer wealth received through the social security system program by generation t, in a similar way. It is the survival weighted, discounted sum of pensions received minus the taxes paid to sustain the social security system. Here, we have: $NT_t^p = \left(\frac{p}{r}\right)^2 \times \frac{n}{p}\rho_{t+2} y_{t+2} - \frac{p}{r}\rho_{t+1} y_{t+1})$. Finally, we can introduce the total net wealth transfer for generation t: $NT_t = NT_t^p + NT_t^e$. Those quantities will be intensively used in the remainder of this paper.

One can easily see that $Y_t + NT_t$ is the right hand side term of equation (5). The intertemporal budget constraint simply aggregates lifetime income and and lifetime transfer wealth.

Solving each generation's maximization program, we get the value of the indirect objective function for generation t:

$$V_t = U(c^*_{1,t}, c^*_{2,t+1}, c^*_{3,t+2}) = u(c^*_{1,t}) + pu(c^*_{2,t+1}) + p^2 u(c^*_{3,t+2})$$

$$V_t = K\Big(Y_t + NT_t\Big)^{\nu}$$

Where K is a constant, a function of the parameters of the model.

We do not model the production part of the economy. We will just assume in the rest of the article that income in each period is a function of the human capital of the generation working in this period. More specifically, we will make the following assumption:

$$y_t = wh_{t-1} \tag{6}$$

where w is a fix wage rate[2].

With this very simple framework, we can easily compute the growth rate of individual income. Combining together equations (2) and (6), we get:

$$y_t = w \times \frac{p}{n} \times (\epsilon_{t-1} y_{t-1})^{\alpha} \times (h_{t-2})^{1-\alpha} \tag{7}$$

[2]We could also assume that $y_t = w_t h_{t-1}$, with w_t following a specific independent path.

But $h_{t-2} = \frac{y_{t-1}}{w}$, so that the growth rate of income per capita at time t is given by:

$$g_t \equiv \frac{y_t}{y_{t-1}} = \frac{p}{n} \times (\epsilon_{t-1})^{\alpha} \times w^{\alpha}$$

The economic growth rate (which aggregates both the population growth and the growth of the production per capita) is simply ng_t.

In a steady state, the parameters for the policies, ϵ_t and ρ_t, are constant across time (ϵ and ρ). As the growth rate of individual income only depends on the value of ϵ (and other exogenous parameters), it also remains constant, $g_t = g$.

We can then compute the indirect value of the objective function for each generation in a steady state. In fact, we have:

$$Y_t + NT_t^e + NT_t^p = \frac{p}{r}\left(\frac{r}{ng}\epsilon + (1-\epsilon-\rho) + \frac{ng}{r}\rho\right) y_{t+1} \tag{8}$$

Therefore, $V_t = K\left(\frac{p}{r}\left(\frac{r}{ng}\epsilon + (1-\epsilon-\rho) + \frac{ng}{r}\rho\right) y_{t+1}\right)^{\nu}$ and $\frac{V_{t+1}}{V_t} = g^{\nu}$.

1.2 Modifying upward transfers only

In this section we discuss the welfare impact of a change of the upward transfers, when the education transfers are held constant.

Proposition 1: *Assume that the economy is in steady state with fixed taxation rates for education and social security. Then, a policy of keeping education transfers constant, and increasing the social security parameter would improve the welfare of the first generation affected by it.*

However, if in the initial steady state the rate of interest is greater than the rate of economic growth, the reform will eventually have a negative impact on the welfare of later generations.

Proof: see appendix.

This result is well known, although it is generally stated differently. It is indeed well known that a decrease of a Pay as You Go pension system would improve the welfare of future generations, but that it would be costly for the first generations affected by the reform. Proposition 1 is simply the symmetrical (and equivalent) result.

Note that although we only prove proposition 1 with our simple framework (in which social security does not affect growth) this property remains true in a more general model with general equilibrium effects on the interest rate. For instance, if we take Kaganovitch and Zilcha's model, we can get the same result. Such a result can also be shown with less specific functional forms. In fact when the rate of interest is greater than the rate of economic growth, an increase in the social security transfers tightens the individual's budget constraint and saving incentives. As a result, in a general equilibrium setting, both physical and human capital investment, and consequently economic growth, are driven down by social security transfers.

1.3 Modifying education transfers only

Proposition 2: *Assume that we are in steady state with fixed taxation rates for education and Social Security and that the rate of economic growth is less than the rate of interest. Then,a policy consisting in keeping Social Security policy constant and increasing the education transfer parameter may reduce the welfare of the first generation affected by it and improve welfare in the long run.*

Proof: see appendix.

Note that contrary to the pension system reform, here the reform has an impact on growth. But this impact has the same direction as the pure effect of redistribution of earning over the lifetime. In a more general model, other effects may exist. First, the increase in the educational transfer may not have such a great impact on human capital accumulation, due to substitution between public and private investment in human capital. It may also have a negative impact on saving which may reduce physical capital accumulation and then growth in a more general model. In fact, the result we provide is true whenever an increase in education transfers actually generates some economic growth, since the impact of education transfers has (in steady state) a positive impact on the individual budget constraints whenever $r > ng$.

1.4 Combining both transfers

We have shown that, with reasonable assumptions, an increase in social security transfers will have a positive impact on welfare in the short term and a negative impact in the long term. The opposite was found for education transfers. As suggested by Becker and Murphy, combination of the two kinds of reform may have a positive impact on the welfare of all generations. This is formalized in the following proposition:

Proposition 3: *There exist Pareto improving transitions from a system without intergenerational transfers to a system with both upward and downward transfers. Such transitions are achieved by first raising educational transfers and then introducing the PAYG system. The net educational (resp. pension) transfer is therefore first negative (resp. positive) and then positive (resp. negative) if the rate of interest is greater than the rate of economic growth. The net intergenerational transfer is first positive and its final sign depends on the new equilibrium.*

Proof: see appendix.

Proposition 3 formalizes Becker and Murphy's argument. We see that for a transition to be Pareto improving, education and pension transfers have to develop in such a way that the net transfer wealth received by the first generations to be affected by the reform is positive. It's interesting to look at historical data to see whether it has been the case in the past. In the long term the net transfers do not need to be positive as a negative distributive impact can be compensated by a greater economic growth. But whether this actually was the case can be studied by looking at historical cohort-specific net transfer wealth and comparing it to lifetime gains that we may attribute to education-related economic growth.

2 Estimation and forecasts of transfers

Data and methods

The historical data for these three programs come from a variety of sources. Here we will briefly describe the data sources and methods used; some further details can be found in the appendix. For public education, age-specific benefit data were derived from census data on school enrollment rates and administrative data on total expenditures. Age-specific tax data were generated based on a balanced budget assumption together with the expenditure totals. We assumed that education was paid for by property taxes, and inferred the incidence of these taxes from census data on home ownership, renter status and income (Qian, 2003). For social security, age-specific administrative data on benefits came from the Social Security Administration. Age-specific tax data was derived from survey data on taxation and administrative data on sources of social security revenue. For Medicare, age-specific benefit data were derived from administrative data on the age-distribution of benefits in 2000 and administrative data on total expenditures. Age-specific tax data were derived from survey data on taxation and administrative data on sources of Medicare revenue. For our historical series, we are more certain of the level of expenditures and taxation than the details of their age-specific allocation.

For the projection, our general technique is to assume a fixed cross-sectional age-shape for benefits and taxes, and to shift the levels of these age profiles upwards at a fixed rate which depends on the rate of productivity growth. However, there are many exceptions. Health care costs are projected to rise more rapidly than productivity growth, following the assumptions of the Medicare Trustees and Actuaries. Social Security benefits are determined for each cohort at retirement, and depend on the history of productivity growth, as well as on legislated changes in the normal retirement age. Our simulation models have been carefully tested against official projections and other projections we have done, and they accurately reproduce these.

Projections indicate that both Social Security and Medicare have major long term fiscal imbalances, and they are unsustainable as currently structured. While we do one set of projections based on current program structure, we also have specified three different adjustments to balance the programs: 1) raise taxes as necessary for period to period balance, once the trust funds are exhausted; 2) cut benefits to achieve balance; and 3) make equal adjustments to both taxes and benefits, which is our baseline assumption.

For education, we assume that there are no further changes in enrollment rates beyond their current levels. We assume a real (that is, inflation adjusted) interest rate of 3%, and productivity growth of 1.4%. We assume that age-specific costs per Medicare enrollee grow 1% faster than productivity through 2080 and then trend down toward the rate of productivity growth. We forecast future mortality rates based on Lee-Carter methods using the trend in the historical US data since 1950, resulting in slightly more rapid life expectancy gains than are projected by Social Security - about three more years of life at the end of the 21st century. The long-run total fertility rate is assumed to be 1.95, following recent Social Security assumptions. Annual immigration is set at 900,000 per year. (Miller, 2004).

Based on these data sources, procedures, projections, and policy assumptions, we have constructed a complete age-time matrix of benefits and taxes for each birth cohort from 1850 through 2090. This matrix is the basis of all the calculations reported below.

3 Empirical Results

Net Social Security and Medicare transfer benefits by birth cohort: 1850 to 2090

As noted earlier, we calculate the net present value for each program and each birth cohort as the difference between the lifetime discounted, survival-weighted benefits and the discounted, survival-weighted tax payments. Figure 1 presents the results for Social Security and Medicare expressed as a percent of lifetime earnings. The creation of social security in the late 1930s (with first regular benefit payments starting in 1950) and Medicare in the mid-1960s led to large windfall gains for the early participants in these pay-as-you-go systems. These early participants received benefits far in excess of the taxes they paid. The Social Security NPVs are highest, at about +4% to 6%, for the birth cohorts of 1890 to 1920, with those born in 1914 experiencing the greatest windfall gain with the net present value of their combined social security and Medicare benefits amounting to 8.1% of their lifetime earnings. Rates of return might be higher for earlier cohorts, but the NPV depends also on the scale of benefits received, not just on their relation to prior contributions.

For cohorts born after 1920, the NPV declines steadily to around -2% to -3% for cohorts born today, based largely on projections for the 21st century. The NPV for Medicare reaches a peak of around 2% for birth cohorts of 1910 to 1960. The NPV declines for cohorts born after 1960 reaching about -1% for cohorts born today.

Under our baseline scenario, the future shortfall in Social Security and Medicare is met in equal parts by raising tax rates and lowering benefit rates. In the case of Social Security, these adjustments begin 2044 when the trust fund is exhausted (according to SSA projections, it is exhausted in 2042). In the case of Medicare, adjustments begin almost immediately. Here we consider three alternative scenarios shown in Figure 2. In the first alternative, future shortfalls are met by cutting benefits. In this scenario, the NPVs are negative beginning with cohorts born in 1956. In the second alternative, future shortfalls are met by raising taxes. In this scenario, the NPVs remain positive until the generation born in 1981, but the NPVs for future generations are more negative than when benefits are adjusted rather than taxes. Finally, we consider the scenario in which there is no adjustment, and the systems are permitted to continue running deficits indefinitely. This is not a sustainable course since it leads to an explosion of debt. In this scenario, the NPV just keeps on rising as a share of life time earnings for generations born after 1960 or so, since taxes are not raised, nor benefits cut. Presumably the benefits are financed by the sale of bonds, for which in reality it is unlikely there would be any buyers since debt to GNP ratios would soar.

Net transfer benefits for Public Education by birth cohort: 1850 to 2090

An individual receives public education benefits at an earlier age than the taxes to fund education are paid. Therefore, such systems create implicit transfer wealth for the government rather than implicit transfer debt (the signs are reversed when we take the perspective of individuals). Whereas initial participants in the social security system received a windfall gain, the first generation to make tax payments to support the public education system receive a windfall loss as they pay for a level of educational benefits which they themselves have never received.

Figure 3 gives the NPV for public education for each birth cohort from 1850 to 2090, calculated with a constant real interest rate of 3%, and expressed relative to the present value of life time earnings for each cohort.

To interpret this figure, first imagine what it would look like if public education were suddenly introduced all at once in one calendar year. In this case, the initial birth cohorts would pay taxes but receive no education themselves, so all would show a negative NPV. The cohort born five years before the start of public education would be ready to start kindergarten at the inception of public education, and would receive the complete education provided. Consider the NPV for this cohort. We know that the internal rate of return for any mature stable transfer system must equal the rate of population growth plus the rate of productivity growth, or the rate of growth of GDP. Since the educational benefit is received before the taxes are paid, we would expect the NPV to be negative if the discount rate is less than the growth rate of GDP, and positive if it exceeds the growth rate of GDP. A 3% discount rate is below the growth rate of GDP for the early part of the period, and so should yield a negative NPV for the fully educated cohorts as well as the initial cohorts. The historical rates of interest should be a bit higher than the growth rate of GDP, and so yield a positive NPV.

In practice, however, public education was not introduced all at once. Instead, enrollment rates gradually increased, and the median educational attainment slowly rose. Relative stability at a median attainment just above high school completion was not attained until some years after WWII. Consequently, for a long time every cohort was in the position of paying taxes to cover the costs of an educational level higher than the one it had received when younger, and consequently the NPVs were depressed well below zero so long as educational attainment kept rising. The first figure shows that the NPV becomes increasingly negative relative to life time earnings until it reaches its trough for the birth cohort of 1930 at around -4%. After this it rises, but does not become positive until the birth cohort of 1960, rising to a plateau at around +4% for the birth cohorts of 1980 to 2000, based almost entirely on projected values of taxes and expenditures for the 21st century.

Those born in the late 1930s experienced the largest windfall losses due to the expansion of funding for public education in the 1960s. For example the birth cohort of 1932 lost 5.9% of lifetime earnings to public education. Because public education was phased in very slowly, the early generations of tax payers suffer only small losses relative to life earnings. But as enrollments and median grade attainments rise, each generation of tax payers is funding a higher level of education than it received itself, so NPVs remain negative. The generations that funded the education of the baby boom generation were hit particularly hard because there were so many students, and relatively few tax payers, and because enrollments in higher education rose rapidly in the 1950s and 60s. For cohorts born 1959 and thereafter, the net present value of public education benefits becomes positive, reaching 7.7% of lifetime earnings for cohorts born in 2004.

Combined Accounts

Figure 4 shows the NPV's for the combined upward transfer (through Social Security and Medicare) together with the NPV for the downward transfer through public education. The first generations to bear the cost of public education were too old to gain from the introduction of Social Security. However, to a considerable extent we see that those generations that benefited from the start-up of the upward transfers were the same ones that bore the brunt of the intensification of the downward transfers associated with financing the education of the baby boom. For example, for the cohort born in 1920, net social security and Medicare benefits amounted to 6.5% of lifetime earnings which were offset by net public education benefit amounting to -5.0% of lifetime earnings, so that net effect of all transfer systems was just +1.5% of lifetime earnings. Similarly, we forecast a future in which net public education benefits amount to +7.7% of lifetime earnings for the birth cohort of 2004, while social security and Medicare account for a net loss of -3.4%. So, the net benefits from all transfer systems for children born today are projected to be +4.3% of lifetime earnings.

This is the generation that is supposed to be socked with an unfair burden by our profligate public policy, by which the current elderly live high on the hog at the expense of future generations. A typical elderly person today was born seventy years ago, in 1934, and experienced a net loss of about two percent of life time earnings, while a baby born today is projected to realize a net gain of 4%! This is the opposite of the story we are accustomed to hearing! Evidently, adding education to the mix dramatically changes the generational equity picture.

While largely mirroring each other, the difference in timing of the introduction and expansion of these transfer programs means that some cohorts received net fiscal benefits and others net fiscal losses. There are two peaks in net benefits. The first peak was centered on the cohort born in 1907 which experienced the large windfall gains from the start-up of social security but missed much of the windfall losses from the expansion of public education funding. On net, the 1907 cohort received net transfers amounting to 4.1% of lifetime earnings. The second peak in net benefit is centered on the cohort born in 1981 which experienced the positive benefits of the educational expansion funded by previous generations and which is projected to avoid the looming net costs of paying the social security and Medicare implicit debt. On net, the 1981 cohort is forecast to receive net benefits amounting to 5.9% of lifetime earnings. NPVs for the three transfers systems combined continue to be positive out to the birth cohort of 2043 in our baseline scenario.

There are three sets of cohorts which experienced net losses through the transfer systems. Those born before 1881 experienced net losses due to the expansion of the public education system. Those born between 1927 and 1947 also experienced net losses. While these cohorts did receive large windfall gains associated with the start-up periods for social security and Medicare, these were more than offset by windfall losses from the expansion of the public education system. Cohorts born after 2043 are expected to incur net losses via the public transfer systems as social security and Medicare loom large relative to education.

Note that our calculations implicitly assume that direct expenditures on public education earn a rate of return equal to the rate of discount we use in the calculation, here 3%. In a sense, then, they assume that the level of investment in education is optimal, so that its rate of return equals that on other assets. But if there are higher returns to education, and most likely there are, then later generations could have negative combined NPVs, and still realize life time gains from the transfer program. We have not attempted to include such possibly higher rates of return in our calculations. In fact, most estimates of the rate of return to education are based not on direct expenditures but rather on the opportunity cost of the students' time, and so might not be an appropriate basis for the calculation. Furthermore, there might well be externalities to education that transcend the individual's returns, such as are incorporated in a number of models of endogenous economic growth. So for now, at least, this straightforward calculation seems to be the best way to go.

Are these results consistent with other generational accounts?

How can these results be consistent with the findings of generational accounting (Auerbach, Kotlikoff and Gokhale, 1991), which finds that future generations will be burdened more heavily than current ones? First, they include explicit government debt. Second, they don't consider how particular future generations fare depending on exactly when budgets are adjusted, but rather they consider how future generations will do in total, from now to forever. We look at particular generations according to particular adjustment policies for the transfer programs. Third, in some versions they did not include education. Fourth, in the original version of generational accounting, future tax regimes for currently existing generations could be different than those of future generations in the same calendar year. In our approach, tax and benefit regimes are defined strictly on a period by period basis, while accounts are kept on a generational basis.

We can compare our calculations of current implicit debt to related calculations by Gokhale and Smetters (2003) who report the net present value of expected future taxes and benefits for the population age 15 and over in 2000, under current program rules with no future budget balancing adjustments. They calculate a NPV of \$16.7 trillion for Medicare and \$10.7 trillion for Social Security. Under our "current law" assumptions, and restricting our calculation to the population 15 and over in 2004, we find \$15.3 trillion for Medicare and \$13.5 trillion for OASI. Our assumptions differ in several respects, most notably they assume a discount rate of 3.6%, a growth rate of GDP per capita of 1.7%. We assume a discount rate of 3% and a productivity growth rate of 1.4.

Summary of empirical results

Here is an overview of some leading points to emerge from the empirical accounts:

- Medicare and Social Security together added up to 8% to the net life time earnings of generations born around in the first two decades of the 20th century, while generations born after 1972 appear to be net losers by amounts that increase for those born more recently. The accounts for old age transfers depend sensitively on the assumptions about whether and what future steps are taken to balance the program budgets.

- Education took an increasingly large bite out of the life time earnings of generations from 1850 up until 1932, when it amounted to a negative 6%. Thereafter it rose rapidly, turning positive in 1954 and reaching a steady +7.7% for generations born after 1993.

- To a striking extent, the NPVs for education across the generations appear roughly equal and opposite to the combined NPV for Social Security and Medicare. The windfall gain for the early generations of the 20th century is cut in half by the losses through education, and the losses through education for the generations born 1930 to 1960 are virtually eliminated by the gains through the other programs.

- Here is the most striking result of all. There is a great deal of concern for the burdens we are unfairly foisting debt on the younger generations through the runaway costs of pensions and health care for the elderly, and we do indeed find increasing large life time losses through these old age transfer programs for all generations born after 1972. However, when we include education in the accounts, these losses are more than offset by gains through the educational system, leaving a *net positive* *balance for generations born up until 2043*, and relatively small life time losses for the generations born over the few decades thereafter. It no longer appears that we are exploiting the now and future young generations by forcing them to foot the bill for our profligate consumption, although the problem of high and rising tax rates, and consequent deadweight loss, remains. Indeed, the elderly of today have negative NPV's, while a baby born today is projected to have a positive one, directly counter to the prevailing view.

4 Discussion

Human capital is one of the main generators of economic growth. As shown by past experience, as well as the ongoing situation in developing countries, public funding of education is the best way to insure that human capital grows quickly. But the "public funding" term translates into "downward transfers" when we substitute the longitudinal point of view for the cross sectional one.

Historical data show that these downward transfers have actually been very costly for some generations. For example, transfers for public education have cost more than 5% of the lifetime earnings of cohorts born between 1920 and 1940. Was it legitimate to ask these generations to give more than 5% of their earnings for future generations who, hopefully, will also have a better life? Or should we see the development of public upward transfers, that did give a free lunch to these generations, as a legitimate counterpart for the financial efforts they were asked to make for public education? Without making a statement about what is legitimate or not, our results simply show that the cohorts born between 1920 and 1940 have been more or less repaid, through Social Security and Medicare, for what the educational transfers cost them.

Nonetheless, there are some generations that have paid (or will pay) more than they received and vice versa. The three kinds of intergenerational transfers we have considered do not cancel out and are actually the source of some financial redistribution between generations.

The first point to notice is that generations born between 1850 and 1881 did pay more than they received. These are generations that were at the beginning of the development of public intergenerational transfers and that were perhaps not compensated by different kinds of externalities. For them the development of the welfare state may well have been costly. The cost remained moderate, however.

Generational accounts turn to positive for cohorts born between 1882 and 1926 and then remain above minus 1% for any cohort we consider in this analysis. But it is clear that human capital development that has been made possible by the development of public education from the middle of the nineteen century, had an effect through economic growth that largely compensate this minor loss. In other words, even if some generations born after 1926 paid slightly more than they received for public transfers, they all benefited from public transfers. Thus, apart from the generations born before 1880, the Becker and Murphy argument is fully consistent with the generational experience.

Nonetheless, the results shown in Figure 4 raise some questions. The first question we may ask is whether upward transfers were only developed to compensate for the development of transfers on education. Our results do not support such a view, since generations born between 1882 and 1926 actually received significantly more from Social Security and Medicare than they paid for public education. Actually, intergenerational transfers considered as a whole did redistribute resources from generations born after 1926 to generations born before 1926. There may have been good reason to do this, since generations born after 1926 had higher lifetime income, but this redistributive aspect should not be ignored.

The question that naturally follows is why the NPV decreased for generations born between 1907 and 1935 and increases for those following. Or in other words, why did the generations born around 1935 have low NPVs, while those born after 1950, that were richer, were given greater NPV? The rationale for the redistributive aspect of intergenerational transfers is therefore not obvious. It may be the case that externalities, and in particular economic growth, were greater for those born around 1935 and that these generations experienced overall gains that are not captured by our analysis, but it is difficult to make any such statement without having a very good understanding about what actually drove economic growth.

Finally, even if the Becker-Murphy theory is consistent with the empirical record, that consistency does not tell us whether the political decisions to develop these transfer programs were informed by the ideas at the core of that theory. Doubtless we should not take the theory literally when it comes to the political mechanisms at work. But one important lesson from these generational accounts is that if one were to look for an interlinked rationale for these programs, the key periods to examine for education are rather different than one would have expected, and may not lie in the 19th century.

Appendix

A Demonstrations of our theorems

In our demonstrations, values with a bar refer to the value of the variable if the steady state policy would have be maintained.

Proof of Proposition 1: Assume that $\forall t < 2\ \rho_t = \rho$, $\forall t \geq 2\ \rho_t = \rho + \partial\rho$ and $\forall t\ \epsilon_t = \epsilon$.

The first generation affected by the reform is the one which is old at date 2: it is the generation born in $t = 0$. The effect on it is a pure "free lunch" effect: it earns an additional $\partial\rho y_2$ in third period. So the net pension transfers for this generation is $NT_0^p = \bar{NT_0^p} + (\frac{p}{r})^2 \times \frac{n}{p} \times \partial\rho \times y_2$ and its indirect objective function becomes: $V_0 = K\left(\bar{Y_0} + \bar{NT_0^e} + \left(\bar{NT_0^p} + (\frac{p}{r})^2 \times \frac{n}{p} \times \partial\rho \times y_2\right)\right)^\nu$. Then the fist generation unambiguously gains from the transition.

On the contrary, generation born in $t = 1$, the effect on the net pension transfers is: $NT_1^p = \bar{NT_1^p} + \frac{p}{r} \times (\frac{ng}{r} - 1) \times \partial\rho \times y_2$, and so is it for all following generations. Therefore, $\forall t \geq 1$, $V_1 = K\left(\bar{Y_1} + \bar{NT_1^e} + \left(\bar{NT_1^p} + \frac{p}{r} \times (\frac{ng}{r} - 1) \times \partial\rho \times y_2\right)\right)^\nu$. If $\frac{ng}{r} < 1$, it is obvious that the impact of the reform is negative on all future generations.

Proof of Proposition 2: Assume that $\forall t < 1\ \epsilon_t = \epsilon$, $\forall t \geq 1\ \epsilon_t = \epsilon + \partial\epsilon$ and $\forall t\ \rho_t = \rho$.

The first generation affected by the reform is the one which is in its middle-age at date 2: it is the generation born in $t = 0$. This generation will have to pay an additional $\partial\epsilon y_1$ during its second period of life, so that its net educational transfers become $NT_0^e = \bar{NT_0^e} + (\frac{p}{r}) \times \partial\epsilon \times y_1$.

Nevertheless, this additional payment will allow more investment in human capital, which will enhance growth. In fact, $y_2 = wh_1 = g \times y_1 = \frac{p}{n} \times (\epsilon + \partial\epsilon)^\alpha \times w^\alpha y_1$. We can rewrite this expression: $y_2 = \bar{g} \times y_1 + (\frac{g}{\bar{g}} - 1) \times \bar{g} \times y_1 = \bar{y_2} + \left(\left(1 + \frac{\partial\epsilon}{\epsilon}\right)^\alpha - 1\right) \times \bar{g} \times y_1$. As the old age benefits of generation 0 depends on y_2, this has an impact on the net pension transfers for this generation: $NT_0^p = \bar{NT}_0^p + (\frac{p}{r})^2 \times \frac{n}{p} \times \rho \times \left(\left(1+\frac{\partial\epsilon}{\epsilon}\right)^{\alpha} - 1\right) \times \bar{g} \times y_1$. Consequently:

$$\begin{aligned} V_0 &= K\left(\bar{Y_0} + \left(\bar{NT}_0^e - \frac{p}{r} \times \partial\epsilon \times y_1\right) + \left(\bar{NT}_0^p + \frac{p}{r} \times \frac{n}{r} \times \rho \times \left(\left(1+\frac{\partial\epsilon}{\epsilon}\right)^{\alpha} - 1\right) \times \bar{g} \times y_1\right)\right)^{\nu} \\ &= K\left(\bar{Y_0} + \bar{NT}_0^e + \bar{NT}_t^p + \frac{p}{r} \times y_1 \times \left(\frac{n}{r} \times \rho \times \left(\left(1+\frac{\partial\epsilon}{\epsilon}\right)^{\alpha} - 1\right) \times \bar{g} - \partial\epsilon\right)\right)^{\nu} \end{aligned}$$

Therefore, the whole effect depends on the sign of $\frac{n}{r} \times \rho \times \left(\left(1+\frac{\partial\epsilon}{\epsilon}\right)^{\alpha} - 1\right) \times \bar{g} - \partial\epsilon$. But if $\frac{\partial\epsilon}{\epsilon}$ is low enough, $\left(1+\frac{\partial\epsilon}{\epsilon}\right)^{\alpha} - 1 \approx \alpha \times \frac{\partial\epsilon}{\epsilon}$. So, we are interested in the sign of: $\alpha \times \frac{p}{r} \times \rho \times \epsilon^{\alpha-1} \times w^{\alpha} \times \partial\epsilon - \partial\epsilon$.

It is negative (and therefore the reform has a negative impact on the first generation), if $\epsilon \geq \left(\frac{p}{r} \times \alpha \times w^{\alpha} \times \rho\right)^{\frac{1}{1-\alpha}}$. We may notice that it implies the reform has always a negative impact on the first generation if ρ is low enough. When PAYG systems are settled, $\rho = 0$, and therefore the first generations suffer from the transition.

The generation born in $t \geq 1$ will, on the contrary benefit from the reform. In fact, after the reform, the growth rate of productivity is $g = \bar{g} + (\frac{g}{\bar{g}} - 1)$. It can therefore be shown that, $\forall t \geq 2$:

$$y_t = \bar{y_t} + \left(\sum_{i=0}^{t-2}\left(\frac{g}{\bar{g}}\right)^{i}\right) \times \left(\frac{g}{\bar{g}} - 1\right) \times \bar{y_t}$$

Recall that:

$$V_t = K\left(\frac{p}{r}\left(\frac{r}{ng_{t+1}}\epsilon_t + (1-\epsilon_{t+1}-\rho_{t+1}) + \frac{ng_{t+2}}{r}\rho_{t+2}\right)y_{t+1}\right)^{\nu}$$

For all $t \geq 1$, $g_{t+1} = g_{t+2} = g$, $\epsilon_t = \epsilon_{t+1} = \epsilon + \partial\epsilon$ and $\rho_{t+1} = \rho_{t+2} = \rho$. Substituting partially y_{t+1} and with some algebra, one can show that:

$$\begin{aligned} V_t = K\Bigg(& \underbrace{\frac{p}{r} \times \left(\frac{r}{n\bar{g}}\epsilon + (1-\epsilon-\rho) + \frac{n\bar{g}}{r}\rho\right) \times \bar{y_{t+1}}}_{\text{Lifetime net earnings without the transition}} + \underbrace{\frac{p}{r} \times \partial\epsilon \times \left(\frac{r}{ng} - 1\right) \times y_{t+1}}_{\text{Effect on net transfer on education}} \\ & \underbrace{+ \frac{p}{r} \times \left(\left(\sum_{i=1}^{t-1}(\frac{g}{\bar{g}})^{i}\right) \times \frac{r}{ng} \times \epsilon + \left(\frac{n\bar{g}}{r} + \left(\sum_{i=0}^{t-1}(\frac{g}{\bar{g}})^{i}\right)\right) \times \frac{ng}{r} \times \rho + \left(\sum_{i=0}^{t-1}(\frac{g}{\bar{g}})^{i}\right) \times (1-\gamma-\rho)\right) \times \left(\frac{g}{\bar{g}} - 1\right) \times \bar{y_{t+1}}}_{\text{Growth effect}}\Bigg)^{\nu} \end{aligned}$$

The growth effect is always positive if $g > \bar{g}$, that is if the reform is growth enhancing. Besides, the transfer effect is obviously positive when $r > ng$. Therefore, all future generation will benefit the reform but maybe the first.

Proof of Proposition 3: It is obvious that the transition in the PAYG system must occur one period after the one in the public education system; if it occurs before, some generation will face losses as the second generation touched by the reform has its welfare decreasing; if occurs after, the first generation touched by the educational reform would face a decrease in its welfare. Therefore, we assume that $\forall t < 2$ $\rho_t = \rho$, $\forall t \geq 2$ $\rho_t = \rho + \partial\rho$, $\forall t < 1$ $\epsilon_t = \epsilon$ and $\forall t \geq 1$ $\epsilon_t = \epsilon + \partial\epsilon$.

First, comparing welfare in steady states and neglecting the growth effect, one can easily notice that a sufficient condition for the transition being Pareto improving in the long run is:

$$(\tfrac{r}{ng} - 1)\partial\epsilon + (\tfrac{ng}{r} - 1)\partial\rho > 0 \tag{9}$$

$$\Longleftrightarrow \quad \partial\epsilon > \tfrac{ng}{r}\partial\rho \tag{10}$$

Thus, the size of the PAYG system must not be too high if the social planner does not want to harm future generations.

The first generation affected by the reform is the one born in $t = 0$. Combining results obtained in proofs of propositions 2 and 3, we get:

$$V_0 = K\left(\bar{Y_0} + \bar{NT_0^e} + \bar{NT_t^p} + \frac{p}{r} \times y_1 \times \left(\frac{n}{r} \times \left(g\partial\rho + \rho \times \left((1 + \frac{\partial\epsilon}{\epsilon})^\alpha - 1\right) \times \bar{g}\right) - \partial\epsilon\right)\right)^\nu$$

Assuming, as before, that $\left(1 + \frac{\partial\epsilon}{\epsilon}\right)^\alpha - 1 \approx \alpha \times \frac{\partial\epsilon}{\epsilon}$, a condition for the first generation to be at least as well-off as without the transition is:

$$\begin{aligned}
& \tfrac{n}{r} \times g \times \partial\rho \geq \left(1 - \tfrac{n}{r} \times \alpha \times \rho \times \tfrac{\bar{g}}{\epsilon}\right) \times \partial\epsilon \\
\Longleftrightarrow \quad & (\tfrac{p}{r} \times \alpha \times \epsilon^{\alpha-1} \times w^\alpha) \times \partial\epsilon \times \partial\rho \geq \left(1 - \rho \times \tfrac{p}{r} \times \alpha \times \epsilon^{\alpha-1} \times w^\alpha\right) \times \partial\epsilon \\
\Longleftrightarrow \quad & \partial\rho \geq \tfrac{r}{p \times \alpha} \times \epsilon^{1-\alpha} \times w^{-\alpha} - \rho
\end{aligned}$$

The increase in the PAYG transfers must be high enough to have the first generation benefit from the positive of its additional transfers to its children. The condition $\epsilon \geq \left(\frac{p}{r} \times \alpha \times w^{\alpha} \times \rho\right)^{\frac{1}{1-\alpha}}$, which means that the transition in the educational policy has a negative impact on the first generation, only implies that $\partial\rho \geq 0$.

One may also notice that $\frac{p}{r} \times y_1\left(\left(\frac{n}{r} \times w\rho\alpha - 1\right)\partial\epsilon + g\partial\rho\right)$ is the impact of the reform on wealth transfers to generation 0, and that it must at least equal 0.

For generation $t \geq 1$, the impact is similar as what we found in the proof of proposition 2:

$$\begin{aligned} V_t \quad = \quad & K\Bigg(\underbrace{\frac{p}{r} \times \left(\frac{r}{n\bar{g}}\epsilon + (1-\epsilon-\rho) + \frac{n\bar{g}}{r}\rho\right) \times y_{\bar{t+1}}}_{\text{Lifetime net earnings without the transition}} + \underbrace{\frac{p}{r} \times \left(\partial\epsilon \times \left(\frac{r}{ng} - 1\right) + \partial\rho \times \left(\frac{ng}{r} - 1\right)\right) \times y_{t+1}}_{\text{Effect on net transfers}} \\ & \underbrace{+ \frac{p}{r} \times \left(\left(\sum_{i=1}^{t-1} (\frac{g}{\bar{g}})^i\right) \times \frac{r}{ng} \times \epsilon + \left(\frac{n\bar{g}}{r} + \left(\sum_{i=0}^{t-1} (\frac{g}{\bar{g}})^i\right)\right) \times \frac{ng}{r} \times \rho + \left(\sum_{i=0}^{t-1} (\frac{g}{\bar{g}})^i\right) \times (1-\gamma-\rho)\right) \times \left(\frac{g}{\bar{g}} - 1\right) \times y_{\bar{t+1}}}_{\text{Growth effect}} \Bigg)^{\nu} \end{aligned}$$

As the reform is growth enhancing, the growth effect is positive. So is the effect on net transfers, if we assume that condition (10) is satisfied, and as long as $r > ng$.

Therefore, to compute a Pareto improving transition, it is only sufficient to find a pair $(\partial\epsilon, \partial\rho)$ satisfying conditions (10) and (11). It is always possible to find such a pair when $r > ng$.

B Methods and Data Sources for Estimates of Generational Accounts

For purposes of this paper, we need calculations of the net present value of benefits received by a member of a generation over the life cycle, minus taxes paid over the life cycle to provide this benefit. The necessary ingredients for the calculation of the net present value (NPV) are an interest rate, r (or a series of interest rates, $r(t)$, for the life time of the cohort: survival rates); survival probabilities $l(x,t)/l(0)$ for each birth cohort; and the cost of the average benefits received by age, $\beta(x,t)$, and taxes paid for this benefit, $\tau(x,t)$, also over the full life cycle. Given these, the NPV for the generation born in year s, with constant discount rate r, is given by:

$$NPV(r) = \int_0^{\omega} e^{-rx} \times \frac{l(x, s+x)}{l(0)} \times \Big(\beta(x, s+x) - \tau(x, s+x)\Big) dx$$

The NPV for Social Security, starting with the first generations to receive any benefits, has been calculated by others (Leimer, 1994; Schieber and Shoven, 1999). Calculations close to this NPV for Medicare, but differing in some important respects, have also been made (Cutler and Sheiner, 2000). Calculations for education have not previously been made. They are not at all straightforward, and have required extensive analysis of historical data, as described below.

Methods for estimating NPV for public education, Social Security, and Medicare

For public education, we estimated benefits, $\beta(x,t)$, and taxes paid for this benefit, $\tau(x,t)$, for birth cohorts from 1850 to 2000. The population, education expenditure and taxes data mainly come from the US Census (Integrated Public Use Microdata Series, or IPUMS). Data are available at the micro level for each census year between 1850 and 1990, except 1890 and 1930. Between available census years, we use interpolation and smoothing to obtain estimates for single calendar years.

Calculating the cost of educational services received by age

In the census data we get from IPUMS, educational expenditures are not given. To calculate the public expenditure per capita for each year, we use public expenditures per pupil, which is either directly available or is derived from total expenditures and total enrolled students (taken from the Historical Statistics of the United States and Digest of Education Statistics). The total enrollment in public schools was calculated by multiplying the enrollment rates from IPUMS by the proportion of total enrollment that was in public schools (that is, we adjusted for private school enrollment). When day care and nursery school enrollments were reported, we eliminated all enrollments under age 5. Expenditure data did not distinguish between elementary and high school. For future years, we assume that the expenditure per pupil for public education will grow at the same rate as the projected labor productivity growth rate, which we assume to be 1.8% per year (in real terms). Incomes by age are likewise assumed to grow at this rate.

Calculating the taxes paid for education, by age

Public education has always been funded mainly by property taxes. We assume that property taxes are proportional to property value. In the census, this value is reported by respondents who own their own homes. Renters report their average monthly rent which we assume is proportional to the value of the property. We use census data from 1940 to 1990 to derive the age profile of home value for heads who own their homes and the age profile of monthly rent for heads who pay rent. Data from the BEA (Bureau of Economic Analysis) give the aggregate value of residential housing by tenure: owned and rented from 1925 to 1990. We use these data to adjust the levels of the two age profiles. We assume that 70% of property taxes on rental properties are passed on to renters in higher rents. The age profile of the value of landlord-owned homes is the same shape as the age profile of owned-home values.

We assume a balanced education budget for each year, so that total taxes paid for education exactly equal total public expenditure on education. The level of the age profile of tax payments is adjusted so that given the population age distribution, the appropriate total of tax payments is generated. Finally, using the survival rates for each cohort, and an interest rate or set of interest rates, we calculate the NPV according to the equation given earlier. We carry out the calculation for a constant real interest rate of 3%.

Calculating the costs and benefits for Social Security and Medicare

For Social Security and Medicare, we can rely on administrative data for the historical period. For the projection period, we rely on simple age- based projection models. These simple models quite closely match the official financial projections issued by the Social Security and Medicare Trustees. We must use our own models rather than rely on official projections for two reasons. First, age profiles of average benefits and taxes are not included in the official projections. Second, we want to be able to perform sensitivity analyses by altering the assumptions about the demographic and economic future.

References

Auerbach, Alan J., Jagadeesh Gokhale, and Laurence J. Kotlikoff (1991), "Generational Accounts: A Meaningful Alternative to Deficit Accounting", in David Bradford, ed., *Tax Policy and the Economy* (MIT Press, Cambridge, for the National Bureau of Economic Research), 55-110.

Becker, Gary S and Kevin Murphy (1988), "The Family and the State", *Journal of Law and Economics*, XXI, 1-18.

Boldrin, Michele and Ana Montes Alonso (1998), "Intergenerational transfers institutions: public education and public pensions", Paper presented at the CEPR/IIEG PBM Workshop on "Rethinking the Welfare Society", La Coruna 27-28 September 1998.

Cutler, David and Louise Sheiner (2000), "Generational Aspects of Medicare", *American Economic Review*, 90(2), May 2000, 303-307.

Gokhale, Jagadeesh, and Kent Smetters (2003), *Fiscal and Generational Imbalances: New Budget Measures for New Budget Priorities* (Washington, D.C.: American Enterprise Institute).

Leimer, Dean R. (1994), "Cohort-specific Measure of Lifetime Net Social Security Transfers", ORS Working Paper No. 59, Office of Research and Statistics, Social Security Administration.

Kaganovich, Michael and Itzhak Zilcha (1999), "Education, social security, and growth", *Journal of Public Economics*, 71, 289-309.

Masson, André (1999), "Économie des solidarités -II- Familles, État et contrat générationnels", Document de travail du DELTA 1999-18.

Miller, Timothy (2004), "A simple projection model of OASI finances", Manuscript, Department of Demography, UC Berkeley.

Qian, Wenlan (2002), "Education Project Report", Manuscript, Department of Demography, UC Berkeley.

Rangel (2000), "Forward and Backward Intergenerational Goods: A theory of intergenerational exchange", NBER Working Paper No. W7518.

Schieber, Sylvester J. and John B. Shoven (1999), *The Real Deal: The History and Future of Social Security* (New Haven: Yale University Press).

Zhang, Jie (1995), "Social security and endogenous growth", *Journal of Public Economics*, 58, 185-213.

Fig 1. NPV at birth of expected lifetime Social Security and Medicare benefits as percent of lifetime earnings

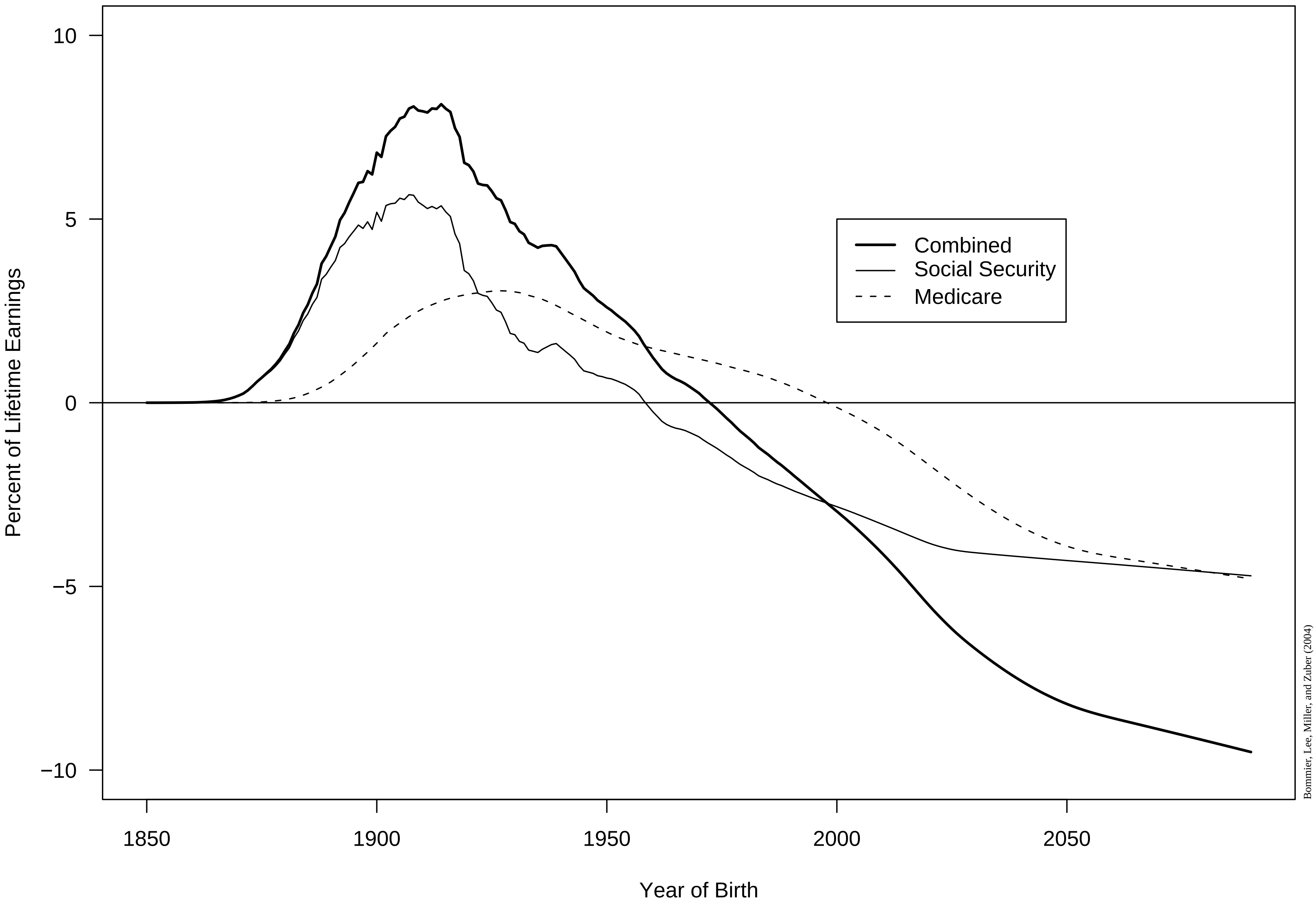

Fig 2. NPV at birth of expected lifetime Social Security and Medicare benefits as percent of lifetime earnings

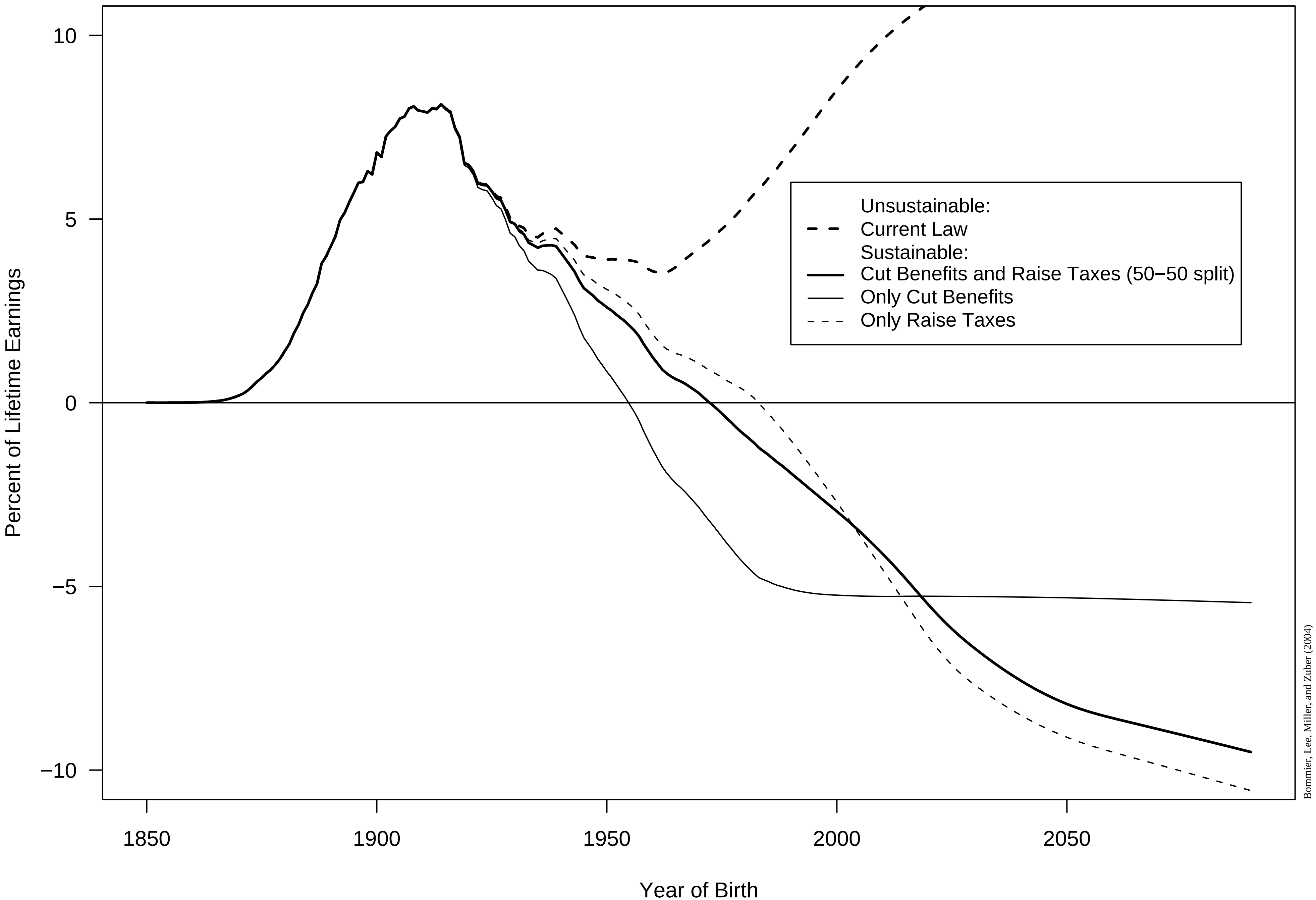

Fig 3. NPV at birth of expected lifetime Education benefits as percent of lifetime earnings

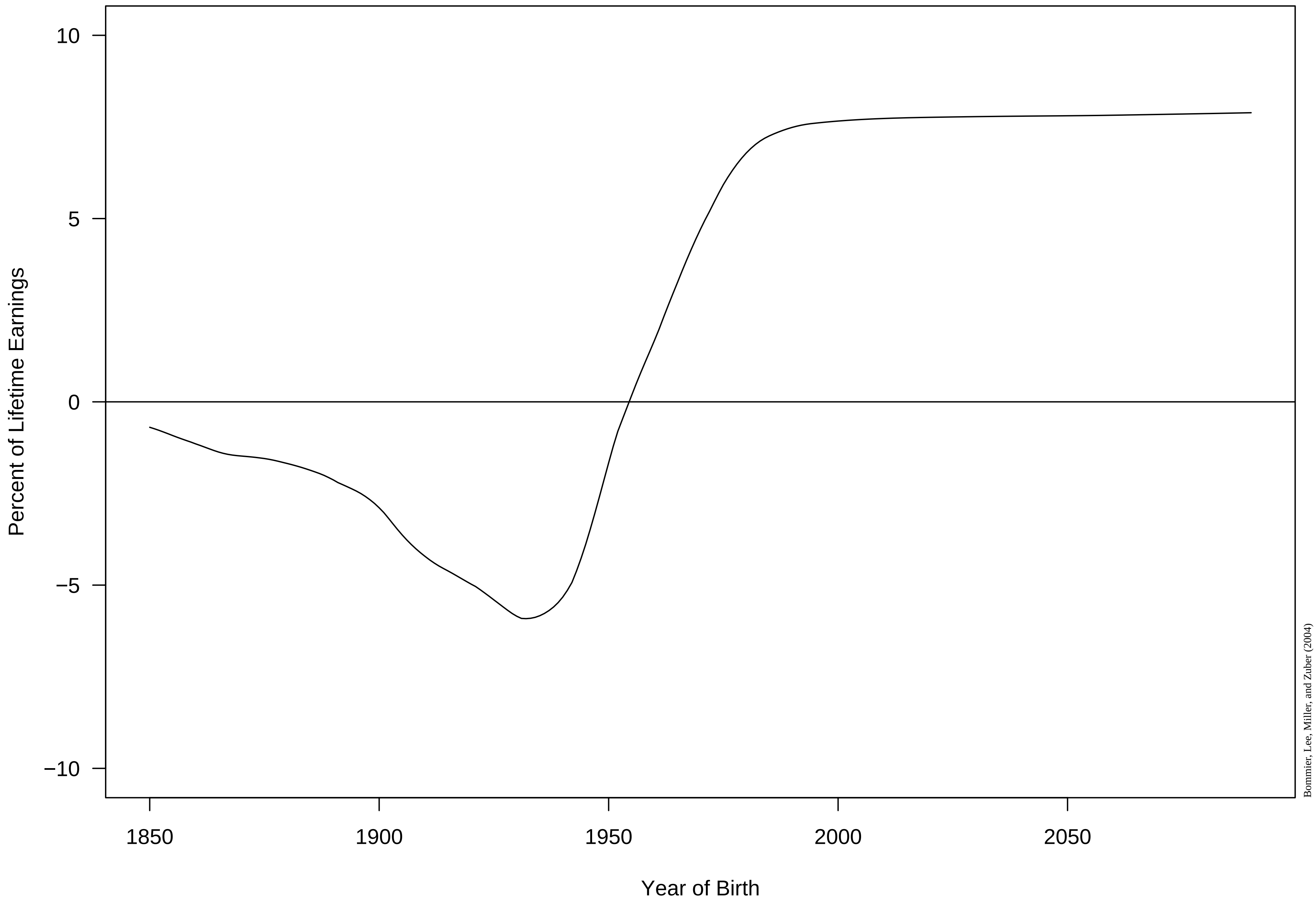

Fig 4. NPV at birth of expected lifetime Education, Social Security and Medicare benefits as percent of lifetime earnings