EXPLAINING THE WEALTH HOLDINGS OF DIFFERENT COHORTS: PRODUCTIVITY GROWTH AND SOCIAL SECURITY

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Abstract

In this paper, we explore the reasons why different generations accumulate different amounts of wealth. We use basic economic theory to propose two indicators of the economic conditions under which households accumulate wealth. The first one represents productivity differences across cohorts: the aggregate level of gross national product per capita around the time the head of the household entered the labor market. The second measure summarizes the changes in Social Security during the head of household's working life. Using panel data from the Dutch Socio-Economic Panel, we show that productivity growth can explain all the cohort effects present in income data, while productivity growth and the generosity of Social Security can explain all the cohort effects present in household net worth. We also find a limited offset of Social Security on wealth holdings.

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1. Introduction

There exists an important debate in the literature on the determinants of saving and wealth accumulation and on how one can explain, for example, the sharp decline in saving that many developed countries witnessed during the 1980s. Some researchers have argued that it is simply the aging of the population that has caused the change in saving. These might be called *age effects*. Others have argued that people coming of age in different times have different preferences. They argue, for example, that generations born after the Great Depression are less thrifty or less alert to risk than previous generations. An alternative view is that preferences may be identical across cohorts, but that the economic conditions of the past are very different from the present. Whether it is preferences or economic conditions, these considerations lead to the supposition of *cohort or generation effects.* Yet another group of researchers have argued that it is the capital gains in the stock market and the housing market that explain the movement in saving. These might be called *time effects*. While all these theories have strengths and weaknesses, the critical issue is: how can we distinguish among age, cohort, and time effects in saving?[1]

Empirically, one cannot disentangle age and cohort effects in wealth data in a single cross-section. Shorrocks (1975) was the first to point out that productivity growth creates differences in household wealth holdings across generations and one cannot simply assume that the elderly provide a good representation of the current young generation when they get older. Thus, solely on the basis of cross-sectional data, one cannot study issues such as whether the elderly decumulate wealth after retirement.

A few authors have used time series of cross sections to study the behavior of wealth or saving.[2] They estimate a wealth or saving equation as a function of age dummies (or a polynomial in age) and cohort dummies. Additionally, one would like to include time dummies, for example to allow for macro shocks. However, this introduces the identification problem mentioned above: calendar time is simply equal to year

[1] See Heckman and Robb (1985) for a detailed analysis of this issue with respect to earnings.

[2] See Attanasio (1998), Deaton and Paxson (1994a), Venti and Wise (1997), and Jappelli (1999).

of birth (cohort) plus age. Some authors, such as Attanasio (1998), simply acknowledge this identification problem and show that one can only identify the age profile of the *changes* in saving but not the age profile of saving itself. Others impose restrictions on the time dummies. The leading approach is the one of Deaton and Paxson (1994a,b) in the context of the life-cycle permanent income hypothesis (LC-PIH) for consumption. They assume that the coefficients corresponding to the time dummies add up to zero and are orthogonal to a time trend. One possible justification for this assumption is that time effects are only due to macro shocks and average out over time. This assumption might be reasonable if the LC-PIH provides a good characterization of household behavior and one has panel data or a time series of cross-sections available with many waves. In our dataset, as is generally the case in existing empirical studies, the number of waves is modest (T=11). Furthermore, our sample period is characterized by dramatic changes in house and stock prices. Since net worth obviously depends on these prices, we have to rely on other identifying assumptions than the one suggested by Deaton and Paxson.

We address the identification problem by exploiting the predictions of a fairly standard version of the LC-PIH to explicitly model the cohort effect.[3] We show that productivity growth and changes in Social Security (SS) together can explain the differences in wealth across cohorts. Productivity differences generate differences in permanent income across cohorts, which then feed into the wealth accumulation of households belonging to different generations. Changes in SS provisions alter the time path of income over one's life cycle and hence affect the need to save for retirement. In our empirical work, productivity of a cohort is proxied by the level of real gross national product per capita (RGNPC) when the head of the household entered the labor market (which we take to be between age 16 through 25). The effect of SS is proxied by a measure summarizing the changes in the SS system during the head of household's life. The inclusion of productivity growth in the regression for household non-capital income renders cohort dummies statistically

[3] There are several earlier papers that model cohort effects as a function of underlying explanatory variables. Important precursors to our approach are Jonson and Klevmarken (1978), Weiss and Lillard (1978), Heckman and Robb (1985), and MaCurdy and Mroz (1995).

insignificant. Thus, our productivity measures appear to capture all cohort effects in income. In turn, permanent income, which include these productivity effects, and our constructed SS variable can explain all cohort differences in net worth.

The advantages of using these measures rather than cohort dummies are several. First, we can determine more clearly the causes for the differences in income and wealth holdings across cohorts. While many potential reasons have been proposed for explaining these differences, simple cohort dummies cannot distinguish, for example, between differences in economic circumstances and differences in preferences. Second, the simple theoretical framework described in the paper highlights that it is very restrictive to use cohort dummies to model cohort effects, since it is easy to envisage cases where the effect is not simply additive, but, as we illustrate for the case of SS, there are interactions between cohort and age effects. Finally, cohort dummies can be rather difficult to interpret when some past economic conditions (productivity growth) lead to an increase in wealth across cohorts, while others (increases in the generosity of SS) lead to a decrease. For policy purposes, it may be very important to disentangle those effects in the data. Our simple economic framework as a basis for the empirical model allows for that.

We estimate our model using panel data from the Netherlands. This is a country whose historical conditions are ideal to study the effects of productivity growth and SS. The Netherlands experienced a steady growth after World War II. At the same time, it also built up a generous welfare system.[4] We find that past economic circumstances can explain the variation in paths of wealth accumulation across cohorts. Thus, we do not need to rely on differences in preferences, e.g. differences in thriftiness or impatience, to explain differences in wealth across cohorts. In particular, our empirical work reinforces the findings of others, such as Shorrocks (1975) and Feldstein (1974, 1996), that productivity growth and Social Security are important determinants of wealth. Furthermore, we find evidence of a limited offset of SS on wealth holdings.

The paper is organized as follows: In Section 2, we present a simple theoretical framework in which we

[4] For details, see van Ark, de Haan, and de Jong (1996).

illustrate the effects of productivity growth and SS on wealth. In Section 3, we introduce the data set and describe the main features of wealth and income over the life cycle. In Section 4, we describe the econometric specification for after-tax household non-capital income and present our empirical results. In Section 5, we report the econometric specification and empirical results for wealth and in section 6 we provide some brief conclusions.

2. Theoretical framework

The theoretical framework underlying our analysis is the simple LC-PIH. In this model, agents accumulate wealth to smooth consumption over the life cycle. Under some restrictive assumptions (e.g. quadratic preferences, complete certainty, equality of the rate of time preference and the interest rate),[5] we can derive closed-form solutions for both consumption and wealth. The expression for consumption is as follows:

$$c_t = Y_p = \left(\sum_{\tau=t}^{L} (1+r)^{t-\tau} \right)^{-1} \left((1+r)A_{t-1} + \sum_{\tau=t}^{L} (1+r)^{t-\tau} y_\tau \right) \quad (1)$$

where c_t and y_t indicate consumption and non-capital income at age t, r is the interest rate which is assumed to be fixed, A is non-human bequeathable wealth (non-pension and non-SS wealth) and L is the length of life. Consumption is equal to permanent income, i.e., the present discounted value of lifetime resources. Wealth at age t is equal to accumulated saving:

$$A_t = (1+r)^{t-1} \left((1+r)A_0 + \sum_{\tau=1}^{t} (1+r)^{1-\tau} (y_\tau - Y_p) \right) \quad (2)$$

If we introduce uncertainty, an expression like (2) becomes considerably more complicated since wealth at age t becomes a function of deviations between expected incomes in the past and their realizations, and of

[5] However, most results concerning the effect of productivity growth can be obtained while relaxing some of these assumptions.

changes in expectations as described in equation (A.3) in Appendix A. If, due to a permanent positive shock, expectations of future income get revised upwards, current consumption increases and this results in lower saving. A prime example of changing expectations about future incomes is provided by the introduction and extensions of the SS system.

2.1. Social Security

In western societies, the introduction of an extensive SS system has greatly reduced the need to save for old age. In the Netherlands, a universal SS system was instituted in 1957 and our data set includes households who were in the labor market well before the introduction of the system.[6] The SS system is essentially pay-as-you-go. SS wealth represents a very important component of total household wealth holdings. According to our calculations, average total net worth (i.e., bequeathable and non-bequeathable wealth) for households whose head is 65-69 years old (in 1987) is approximately Dutch Guilders (Dfl) 440,000, of which more than Dfl. 228,000 is accounted for by SS (medians are Dfl. 354,200 and Dfl. 246,700). For other age groups we find similar results. Thus, about half of total wealth holdings of the elderly in the Netherlands is accounted for by SS.[7]

Appendix A investigates in detail the effect of the introduction and changes in SS on consumption and wealth accumulation in the framework of the LC-PIH. Here we only sketch the main argument. The key assumption is that the introduction of SS leads to a permanent (and unanticipated) increase in income at retirement. We consider two cases; in the first one, pre-retirement income is unchanged and in the second, pre-retirement income falls because a payroll tax is levied to finance SS.

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[6] The General Old Pension Act (AOW) of 1957 introduced Social Security to the entire Dutch population. Some pension provisions were present from 1947 onwards, but they were restricted to some small groups of the population, mainly the very poor and civil servants. See, also, van Ark, de Haan, and de Jong (1996).

[7] For details, see Alessie, Lusardi, and Kapteyn (1995).

We start by considering the case where pre-retirement income is unchanged. Given the unanticipated increase in life-time resources, consumption increases while saving decreases. Thus, the unanticipated change in SS creates a reduction in household (private) wealth. In Figures 1a and 1b, we provide a simple illustration of the effects generated by the introduction of SS. For simplicity we assume that, after its introduction, the level of SS benefits remains constant at a flat amount (about Dfl 15,000). We consider three individuals, all with identical lifetime non-capital incomes before retirement (which starts at age 65). The first individual, who is a representative of the "old cohort," lived in a time without SS and his/her income after retirement drops to zero. His/her consumption is constant across the whole life-cycle and equal to about Dfl. 26,000. The second individual, a representative of the "middle aged cohort," was 50 years old when the SS system was first introduced. He/she will receive SS benefits at retirement. The introduction of SS at age 50 represents an unanticipated increase in life-time resources. Consumption and permanent income of this individual increase. The size of the increase can easily be derived from equation (1). The third individual, a representative of the "young cohort," was 35 years old when SS was introduced. For this individual as well, the introduction of SS represented an unanticipated increase in life-time resources and his/her consumption shifts upward as well, but not by as much as for the middle aged individual, since the increase in life-time resources has to be spread out over a longer remaining life-time.

The shift in consumption affects saving. Since pre-retirement non-capital income is not affected by the introduction of SS, pre-retirement saving goes down by the same amount consumption goes up. Thus, pre-retirement wealth decreases by an amount which is equal to the discounted sum of past and current changes in permanent income (or consumption). The implied wealth profiles are given in Figure 1b. In comparison with the old cohort, the effect of SS on wealth for the middle aged cohort at different ages is given by the vertical difference between the curve ACD and the curve AFGD. Similarly, the vertical difference between ACD and ABED represents the effect of the introduction of SS on the wealth accumulation of the youngest cohort. In Appendix A, we show that this effect, which is summarized by the variable DSS_t, can be written

as a function of the SS benefit levels, the interest rate, the retirement age, and the age of death (see (A.7) and (A.9) in Appendix A). While the graphs are based on the assumption that SS benefits remain constant over time, in Appendix A and in our empirical work, we allow SS benefits to change over time.

The graphical analysis highlights another important aspect of the introduction of SS. The displacement effect created by SS depends not only on the year when SS was introduced but also on the age of the individual at that time. In other words, there is an interaction between age and cohort effects, which cannot simply be summarized by cohort dummies. Thus, it is important to rely on the theory to interpret the meaning of cohort dummies.

We next consider the case where pre-retirement income falls because SS is financed through a payroll tax. The effects on wealth accumulation are qualitatively the same. This follows directly from the certainty equivalent set-up. Given the age of retirement, savings during the working life are simply a function of the difference in income between retirement and the working life. An increase in income during retirement therefore has the same effect as a reduction in income during the working life.

An econometric analysis of equation (2) would require the complete income history of each individual and the history of the variables that are relevant for wealth (such as taste shifters, demographics, etc.). We do not have such data at our disposal. Rather, we have a panel of households covering eleven years with wealth information (see Section 3 for a description of the data). To be able to estimate an equation like (2), we therefore need to apply some approximations. As a first approximation, we assume that wealth at the beginning of life, A_0, can be ignored. Furthermore, upon dividing both sides of equation (2) by permanent income we obtain:

$$\frac{A_t}{Y_{pt}} = (1+r)^{t-1}\left(\sum_{\tau=1}^{t} (1+r)^{1-\tau} \frac{(y_\tau - Y_{pt})}{Y_{pt}} \right) \tag{3}$$

The right hand side can be approximated by a function of age and other variables that may affect the relative

difference of current income and permanent income. Since we use household data, these other variables may include family composition, education of the head of household, etc.

The introduction of a displacement effect due to the introduction or changes in SS into (3) is straightforward. Let DSS_t^k be the additive displacement effect of SS on wealth at age t of generation k. We sketched above how this variable is constructed. Equation (3) becomes:

$$\frac{A_t}{Y_{pt}} = (1+r)^{t-1}\left(\sum_{\tau=1}^{t} (1+r)^{1-\tau} \frac{(y_\tau - Y_{pt})}{Y_{pt}} \right) - \beta \frac{DSS_t^k}{Y_{pt}} \tag{4}$$

If the LC-PIH is correct and if the introduction of and changes in SS does not affect pre-retirement income, then $\beta = 1$. If pre-retirement income goes down as a result of the introduction of SS (e.g. through the levying of a payroll tax), the parameter β is greater than 1. In appendix A, we show that, when SS is financed as a pay-as-you-system, the parameter β is approximately equal to one plus the old age dependency ratio (i.e., the ratio of the number of SS recipients to those who pay SS taxes). In the Netherlands, this ratio is equal to about 0.2.

While the basic framework here is the LC-PIH, qualitatively the findings concerning the effects of SS on consumption and savings will also hold under different models, such as a precautionary saving model (assuming CARA preferences) or a model with uncertain life-time or a bequest motive. The effect of these extensions is to induce extra motives to save during the working life and to reduce decumulation after retirement (see, e.g., Hurd (1989, 1998), and Browning and Lusardi (1996)). However, SS has effects on wealth accumulation in the same direction as in the current model. One should also note that the strength of other saving motives will depend on the institutional environment. For instance, Samwick (2003) finds that during the first phase of the life cycle, the precautionary saving is much more important than the retirement saving motive. However, this conclusion is based on U.S. data. With its very extensive welfare system and employment protection, income uncertainty in the Netherlands is substantially lower than the US and buffer

stock saving may be expected to be quantitatively less important.

Another simplification in the model introduced above is the absence of labor supply responses, as utility is assumed to depend on consumption only. In a model with both consumption and leisure in the utility function in a non-separable way, one expects an effect of the introduction of SS also on the timing of retirement since the introduction of SS increases lifetime resources for the older cohorts (the expected present discounted value of their SS benefits is greater than the value of the extra payroll tax). This increase in lifetime resources may conceivably be consumed in the form of more leisure, e.g., through early retirement. This in itself increases the need to save for retirement and hence may offset the depressing effect of SS on savings.[8] For example, Costa (1995) looks at pension data for the US and finds that the introduction and growth of Social Security and pensions play a major role in explaining the retirement behavior among Union Army Veterans. When we looked at historical data for the Netherlands, we find that the labor force participation rate of those 65 and older dropped from 20% in the 1940s to 11% in 1960 and to 6% at the beginning of the 1970s. The decline is quite strong for men. Male labor force participation after age 65 goes from 36% in 1947 to 11% in 1971.Thus, as already mentioned by Feldstein (1974), the effect of Social Security on savings is ambiguous ex-ante, as there are in principles two offsetting effects of Social Security on savings. The parameter ß may be attenuated substantially by the effect of SS on retirement. This is why we need to turn to the data to address this question. Before we do so, we introduce the effects of productivity growth on savings.

2.2. Productivity growth

To examine the effect of productivity growth on the wealth holdings of different cohorts, we compare wealth levels at age t of two different generations: c_1 (the younger cohort) and c_2 (the older cohort) in the presence of productivity growth. We consider a simple case of productivity growth by modeling the income

[8] See, for example, Feldstein (1974) and Diamond and Hausman (1984).

of households *h* and *i* belonging to two different cohorts as follows:

$$\ln y_{th}^{c1} - \ln y_{ti}^{c2} = G_{c1}^{c2} + \omega_{thi} \tag{5}$$

where G_{c1}^{c2} is a constant specific to the cohorts c_1 and c_2 and ω_{thi} represents all other sources of differences between the incomes of households *h* and *i*, e.g. differences in education of the household head, the number of earners, etc. Importantly, ω_{thi} is not a function of the cohorts to which these households belong. Thus (5) states that, *ceteris paribus*, at any age *t*, the earnings of the two cohorts differ by a constant of proportionality, reflecting, for example, the higher salary at the start of the career of the younger cohort c_1. This assumption is clearly restrictive. For example, it assumes that different cohorts expect the same profile of income over the lifetime. However, workers, particularly those with high education attainment, may differ both in the level and the shape of the income profile. Similarly, a college education obtained in the 1950s when college degrees were rare may have different effects on income than one obtained in 1970s when college were more common, while degrees obtained in the 1970s may have a similar effect on income than degrees obtained in the 1980s. While restrictive, other authors have used similar assumptions and it is important to test it against the data.[9]

In our empirical work, we will relate the multiplicative cohort effect G_{c1}^{c2} to the value of RGNPC around the time the head of the household entered the labor market. Since we don't know when exactly the respondents in the panel entered the labor market, we allow the cohort effect to be a weighted average of RGNPC in the years covering the household head's ages 16 through 25.

3. The data

The empirical analysis is based on the Netherlands Socio-Economic Panel (SEP), conducted by Statistics Netherlands. The SEP is a longitudinal household survey representative of the total population, excluding those living in special institutions like nursing homes. The first survey was conducted in April 1984. The same

[9] See Deaton (1999) for a similar assumption about the impact of productivity growth on the income process. See, however, the discussion and findings in Viard (1993).

households were interviewed again in October 1984 and then twice a year (in April and October) until 1989. In the years since 1990, all information has been collected in one interview, in May of each year. In the October interview, information was collected on socio-economic characteristics: demographics, income, labor market participation and hours of work. In the April interview, information was collected on socio-economic characteristics as in the October interview, but, rather than collecting data about income, from 1987 onwards, information was collected on assets and liabilities. In this paper, we use income data from 1984 until 1997, and wealth data from 1987 until 1998. While income data is measured retrospectively (income questions in a given year refer to income in the previous calendar year since 1989), wealth data pertains to April of the current year. All monetary units have been deflated using the Consumer Price Index and are expressed in 1987 guilders.

An evaluation of the quality of the SEP data and a comparison with macro statistics or other micro data sets is reported in Alessie, Lusardi and Aldershof (1997). We can briefly summarize their findings as follows: the data on some major components of wealth, such as housing, mortgage debt, and checking accounts are well reported in the SEP and compare reasonably well with aggregate statistics. However, some other components, in particular stocks, bonds, and savings accounts seem under-reported in the SEP, and the level of measurement error may also change over time. This problem is typical of wealth surveys and can be found in other similar data sets.

We have deleted from the sample those cases with missing or incomplete responses in the asset and liability components and in the demographics.[10] We have also excluded the self-employed from the sample. The quality of wealth data is very poor for these households, and additionally, wealth data for the self-employed are not available after 1989. Due to these selections, we find that both low and high wealth households have a tendency to drop out of the sample. We will take selectivity into account in our empirical

[10] In many cases, missing data on assets and liabilities could be imputed. See Camphuis (1993) for more details on the data imputation and Alessie, Lusardi and Aldershof (1997) for a description of the criteria used to calculate total net worth.

work.

We start the empirical analysis by reporting some basic facts about income. In particular, we first examine whether there is evidence of productivity growth in the raw data. This analysis provides initial insights to perform the empirical work. We have re-arranged the data as follows: We have defined twelve cohorts by choosing a 5 years-of-birth intervals and have considered all households, from the ones born in 1911-15[11] (they are 72-76 years old in 1987) until the ones who represent the youngest generation (they are born in 1966-70).[12]

In Figure 2, we plot mean household non-capital income from 1984 to 1997 for each cohort. Non-capital income is defined as household earnings net of taxes plus all transfers (including SS benefits and other pensions). For clarity, the graphs only indicate the average year when the head of the household was born (for example, "38" refers to heads of households born between 1936 and 1940). The vertical difference between lines measures the "cohort-time" effect. The difference along the same line measures the "age-time" effect. We use this terminology to emphasize that it is not possible to disentangle age from cohort and time effects in these figures.

Non-capital income has been increasing strongly across cohorts up to the households born in 1928 or earlier. The biggest cohort-time effect is between the cohort born between 1936-1940 and the one born between 1931-1935.[13] The age-time effect is also large. In particular, the young and middle-age households experience a sizable increase in non-capital income as they move along in their career.

The effects across cohorts could simply reflect changes in the labor force participation of Dutch households. For example, female labor force participation has been increasing over time, and the fraction of

[11] Whenever we speak of the age of a household we mean the age of the head of the household.

[12] For a detailed explanation of this methodology, see Browning, Deaton and Irish (1985) and Attanasio (1998). Note that we have deleted the households whose head is younger than 22 (in 1987) to exclude the persons still in school, and the households whose head is older than 76 (in 1987) to partly avoid the strong correlation between mortality and wealth holdings. See also Attanasio and Hoynes (2000).

[13] Historically, wage controls were implemented in the 1950s, but these controls were lifted in the early 1960s and wages grew substantially in that period. Growth came to a halt in the 1970s with two severe recessions.

families with two earners has increased considerably. The SEP data show that there has been a substantial increase in the labor force participation among young couples and there is a strong cohort-time effect for couples whose head is 50 years or younger. However, these effects are still present in the per earner income data. Thus, there is still evidence of productivity growth in individual income.

Turning to wealth, we use two measures of household wealth: financial net worth and total net worth. The first measure is obtained by summing the amounts reported in checking accounts, saving certificates, bonds, stocks, options and other such securities, cars, claims against private persons and subtracting the total amount of debt (which is composed of loans and credit, installment credit, other debt and loans).[14] Total net worth is obtained by adding to financial net worth the value of the house and other real estate, the home-owner's insurance policy, and subtracting the mortgage debt. We consider these two measures of wealth to assess the importance and role of housing equity.

In Figure 3a, we plot mean net worth from 1987 to 1998 for each cohort. As for income, there are substantial cohort-time effects as well as age-time effects in total net worth. Within the same cohort, mean net worth is steadily increasing over time. This is particularly true for the younger and middle-aged cohorts, but even for some elderly, mean net worth continues to increase over time. As expected, a large part of the wealth accumulation is done by the middle age cohorts (households born between 1931 and 1945). For example, the increase in mean net worth over the 11-year period is as big as Dfl. 134,000 for the generation born between 1946 and 1950. Figure 3b, which displays mean financial wealth across cohorts, confirms the findings of Figure 3a. For the older cohorts, the increase in average financial wealth is more pronounced than that of net worth. However, this may simply result from differential mortality among the very old (Hurd (1990)). Looking across cohorts, we find that there are also large differences in wealth accumulation. The biggest cohort-time effects in net worth are experienced by the households born between 1931 and 1940. These effects are present both in the mean and in the median. Cohort-time effects are also present in financial

[14] The reason why we include durables, such as cars, in this definition of wealth is because we cannot distinguish between car loans and other debts.

net worth. Of course, time effects alone could explain the size and magnitude of the differences in wealth accumulation across cohorts. As mentioned in the introduction, different explanations have been offered to explain wealth, but it is not possible to disentangle age, cohort and time effects in the raw data.

Given the differences between financial net worth and total net worth, we have investigated housing equity separately. Housing is an important asset in household portfolios, but strong cohort-time effects remain in non-housing wealth (see also Figure 3b). We have also looked at the effects of capital gains in bonds and stocks on wealth accumulation. Excluding capital gains on housing and stocks, we found that the cohort-time effects in wealth remain sizable. It is therefore unlikely that cohort-time effects can be explained simply by a change in housing prices or other time effects, while productivity growth and other economic circumstances remain potentially important explanations for the pattern of wealth holdings across cohorts.

4. Econometric specification for income

In the econometric analysis, we take an unbalanced panel and consider household income between 1984 and 1997 and household wealth between 1987 and 1998. As equation (3) makes clear, to explain wealth accumulation of households, we need to first model non-capital incomes over the life cycle. In doing so, we will seek to account for cohort differences in productivity. We consider the following fairly simple model to describe household income:

$$\ln(y_{sh}) = \zeta_0 + \sum_{i=1}^{Imax} \zeta_i s_i(age_{sh}^{i}) + \sum_{\tau=1985}^{1997} \gamma_\tau TD_{\tau s} + \sum_{i=2}^{14} \Delta_i LD_{ish} + \sum_{i=2}^{13} \phi_i SD_{ish} + X'_{sh}\beta + u_h + \epsilon_{sh} \qquad (6)$$

where s = time index, s=1984,..,1997;

h = household index;

y_{th} = non-capital income of household h in year s;

age_{sh} = age of the head of the household in year s;

s_i= linear spline function;

$TD_{\tau s}$ = time dummies, equal to one if τ=s, and zero otherwise;

LD_{ish} = learning dummies;

SD_{ish} = selectivity dummies;

X_{sh} = vector of demographic and socio-economic characteristics;

u_h = individual effect;

ϵ_{sh} = random i.i.d. error term with mean zero and variance σ^2_{ϵ}.

In equation (6), we specify a flexible relationship between income and age by considering a linear spline with a number of knots to be determined by the data. In the vector of demographic and socio-economic characteristics, X_{sh}, we have included the following variables: number of adults in the households, number of children in different age groups (6 or younger, between 7 and 12, between 13 and 17, 18 years or older), the gender of the head of the household, and dummy variables indicating the education level of the head of the household (primary, lower secondary, higher secondary, and university education).

Selectivity dummies (SD_{ish}) are defined as follows: SD_{ish}= 1 if the household participates in year s and participates at least one more time in the survey after period s. Otherwise the dummy is equal to zero. The dummies pick up the possibility that respondents who participate at least one more year are different from those who drop out.

To allow for the possibility of learning effects, "learning" dummies (LD_{ish}) have been included. Our motivation is that, as households participate in the survey, they become either better or worse (for example less careful) in answering the questionnaire. The learning dummies are defined by the number of times households participate in the survey. The first learning dummy for a household in a particular wave is equal to one if the household participates in that wave for the first time. The second learning dummy is equal to one if the household participates in that wave for the second time, etc. Since the sample period for the income equation covers 14 periods, the maximum number of times a household participates is equal to 14. Notice that

in a balanced panel, LD_{ish} is just a set of time dummies. In other words, one cannot distinguish between learning effects and, for example, macroeconomic shocks. However, we work with an unbalanced panel and we can distinguish between these effects. A similar comment can be made regarding the selectivity dummies.

The individual-specific effect, u_h, in equation (6) represents unobserved heterogeneity. We want to allow for the possibility that the individual effects are correlated with other right-hand-side variables. It is well-known after the work of Mundlak (1978) that this can be done in two equivalent ways. One possibility is to assume that individual effects are fixed and estimate them as individual parameters. The second possibility, which we choose, amounts to modeling the individual effect by making it dependent on household specific means of all time varying right-hand-side variables. Furthermore and most importantly, we want to allow for cohort effects by making the individual effects dependent on the year of birth of the household head. Let W_{sh} be the matrix of all time varying explanatory variables on the right hand side of (6), plus a column of ones. That is, W_{sh} includes X_{sh}, the time dummies, learning dummies, and selectivity dummies. Define $\bar{W}_{\mathrm{h}} \equiv 1/\mathrm{S}\ \Sigma_{\mathrm{t}} W_{\mathrm{sh},}$ i.e., the time average of W_{sh}. We then model the individual effects as follows:[15]

$$u_h = \bar{W}_h' \gamma + \sum_{c=1912}^{1970} \delta_c CD_{ch} + \theta_h \qquad (7)$$

where CD_{ch} = cohort dummies; c = year of birth cohort index which goes from1912 to1970 (i.e., we include a full set of cohort dummies). Notice that in equation (7) we have not modeled explicitly the cohort effects (we return later to this issue). As Mundlak's argument implies, we may assume that the individual effects θ_h are random and uncorrelated with the explanatory variables. The inclusion of individual effects has the additional advantage that it takes care of all selectivity that is dependent on time invariant factors.[16]

If we insert (7) into (6), we obtain an equation where income is a function of time, cohort, and age effects. The problem, however, is that, as mentioned before, we cannot disentangle age, cohort and time effects from

[15] Without loss of generality we can omit from $\bar{W}_{\mathrm{h}}$ the mean values of the age splines, since in a balanced panel the means are linearly related to cohort specific variables.

[16] See Verbeek and Nijman (1992).

each other. Deaton and Paxson (1994a,b) deal with this identification problem in a clever way. They assume that the coefficients corresponding to the time dummies add up to zero and are orthogonal to a time trend. Notice, however, that the model of Deaton and Paxson is observationally equivalent to a model in which one arbitrarily deletes one cohort, time or age dummy. In other words, Deaton and Paxson's model is just-identified.

In our approach, we explicitly model the cohort effects. We assume that the cohort effects are driven by productivity differences across generations, as represented by equation (5). We relate the multiplicative cohort effect to the value of RGNPC around the time the head of the household entered the labor market, which we take to be between ages 16 through 25. Thus the productivity indicator for a household is a weighted average of RGNPC for the years that the household head was between 16 and 25. To impose some smoothness on the weights and, at the same time, maintain flexibility, we have modeled the weights as Almon lags. We let the degree of the Almon polynomial be determined by the data.

4.1. Empirical results for income

The estimation results of our preferred specification are summarized in Table 1. For clarity, we do not present the estimated coefficients for the demographic variables, time dummies, learning dummies, and selectivity dummies. Their statistical significance is summarized by χ^2-tests presented at the bottom of the table. The preferred specification is the result of a sequence of specification tests. First of all, we estimate income regressions by education levels. A model with just additive education effects but no interactions is decisively rejected against the model presented in Table 1 ($\chi^2(306)=2647$, p=.000). A model with full age and education interactions but otherwise identical coefficients across education levels was also rejected ($\chi^2(261)=1621$, p=.000).

The number of knots in the linear spline for age has been the result of specification testing against a model with a full set of age dummies. At 15 (equally spaced) knots, the specification cannot be rejected; the p-values

for the four education levels are respectively .312, .070, .350, .325. We plot the implied age functions for the four education levels in Figure 4. Education level 4 clearly enjoys a steeper age income profile than the other three education levels. The age-income profiles of education levels 2 and 3 are rather similar. For education levels 1, 3 and 4, we observe a drop in income after age 55. Across all education levels, the selectivity dummies appear to be jointly insignificant, while the learning dummies are only significant for education level 3. The time dummies are significant for the highest education level.

Turning to the modeling of cohort effects, as we have explained in section 2 and the preceding subsection, our maintained hypothesis is that the cohort effects can be explained by productivity growth. The degree of the polynomial in the Almon lag has been determined by "testing down" until a further reduction in the degree of the polynomial was rejected against a more flexible specification. This procedure has led us to choose a quadratic. In other words, we consider a linear combination RGNPC at ages 16 through 25 of the form:

$$\sum_{i=1}^{10} \beta_i Y_{26-i} \tag{8}$$

where y_{26-i} indicates RGNPC at age *26-i*, *i=1,...10,* and:

$$\beta_i = \eta_0 + \eta_1 i + \eta_2 i^2 \tag{9}$$

Inserting (9) into (8) yields:

$$\begin{aligned} \sum_{i=1}^{10} \beta_i Y_{26-i} &= \eta_0 \sum_{i=1}^{10} Y_{26-i} + \eta_1 \sum_{i=1}^{10} i\, Y_{26-i} + \eta_2 \sum_{i=1}^{10} i^2 Y_{26-i} \\ &\equiv \eta_0 rgnpc1 + \eta_1 rgnpc2 + \eta_2 rgnpc3 \end{aligned} \tag{10}$$

with *rgnpc1, rgnpc2, rgnpc3* implicitly defined. The estimates for η_1, η_2, η_3 are reported in Table 1. They are jointly significant for the three lowest education levels, but not for the highest level.

In order to check the validity of our model, we carried out the following misspecification test: we add to

our model 55 arbitrarily chosen cohort dummies.[17] Using a Wald test, we test the joint null hypothesis that the coefficients corresponding to the cohort dummies are equal to zero. If this null hypothesis is not rejected, we can conclude that cohort effects are effectively described by the three variables representing productivity growth.

A test of the model with *rgnpc1, rgnpc2, rgnpc3* against a model which includes 55 extra cohort dummies does not lead to rejection. Table 1 shows that the p-values for the four education levels are respectively: .655, .08, .879, .387. Thus, our simple productivity model is capable of explaining all cohort differences in non-capital household income.[18] Given that we have adequately modeled the cohort effects, we can pin down the time effects and the relationships between non-capital income and age.

Figure 5 presents the weighted average of RGNPC over the years when the head enters the labor market (16 to 25) as a function of birth-year (see equation (10)) for education level 1. Results are roughly the same for other education levels except for the highest education level for which we do not find an effect for RGNPC. The function is upward sloping for most of the cohorts, supporting the productivity growth hypothesis. While RGNPC increased steadily over time, it also experienced variation, particularly around the time of recessions. The nonlinear shape of this function is precisely what allows us to distinguish among age, cohort and time effects.

One may worry that we have run into a spurious regression problem; apart from productivity growth, there may be other (unobserved cohort) effects which might explain non-capital income and which are positively correlated with the productivity growth variables. Since we control for time and age effects, the linear part

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[17]In our dataset, 60 different year-of-birth cohorts can be distinguished (1970 - 1911). Normally, we could add 59 cohort dummies to our model. However, since calendar year=year of birth+age, we can only add 58 dummies. Moreover, our model already contains 3 cohort-specific variables, namely rgnpc1, rgnpc2 and rgnpc3. Consequently, we can only add 55 arbitrarily chosen cohort dummies and test for their joint significance.

[18]Acceptance of the null of no (remaining) cohort effects also avoids the potential problem that the errors in the equation would exhibit a cohort effect. Such a structure would be different from the assumed error component structure where there are only individual effects and a white noise error term, and hence would invalidate all standard errors and statistical inferences drawn on the basis of them. In fact the Wald-test used here is closely related to the F-test proposed by Moulton and Randolph (1989) to detect group effects in the equation errors.

of these variables is already accounted for, so the fact that all variables trend upward over time by itself is not part of the identification. Since non-linearities in these variables is what drives identification, we probe the robustness of our results by including a quadratic in cohort and seeing whether the RGNPC variable still matter and in the same manner. Adding a quadratic in birth year is a specification test against certain other slowly evolving factors. For all education levels, the coefficients corresponding to our added variable (*year-of-birth squared*) do not differ significantly from zero (the p-values are: 0.078, 0.75, 0.283, 0.094). Furthermore, the variables *rgnpc1, rgnpc2, rgnpc3* remain jointly significant for the first three education levels. Finally, Figure 5 remains unchanged if we use the estimates for the coefficients corresponding to the variables *rgnpc1, rgnpc2,* and *rgnpc3* in the new specification.

5. Econometric specification for wealth

We now turn to the formulation of the empirical specification for wealth. Equation (4) serves as a starting point:

$$\frac{A_t}{Y_{pt}} = (1+r)^{t-1}\left(\sum_{\tau=1}^{t}(1+r)^{1-\tau}\frac{(y_\tau - Y_{pt})}{Y_{pt}}\right) - \beta\frac{DSS_t}{Y_{pt}} \qquad (11)$$

We construct permanent income using the estimated model for income described in the previous section. See appendix B for details on the construction of this measure. The first term on the right hand side is approximated by a linear spline in age (with 15 equally spaced knots), and adding demographics and education controls. As a result, the structure of the equation for wealth is quite similar to that for income. As explained in section 2 and appendix A, the second term of (11) measures the displacement effect of SS. The construction of this variable implies an interaction of age and cohort effects. Thus, simple cohort dummies would not be able to approximate the effects of SS.

Note that, by dividing wealth by permanent income, we have already accounted for cohort effects in wealth due to productivity growth. Furthermore, if the PIH model were true, we would not need to add any additional

cohort variables among our regressors. However, the permanent income model is only an approximation of the behavior towards wealth accumulation. Additionally, as found by King and Dicks-Mireaux (1982), preferences could be non-homothetic. Therefore, we add permanent income to the set of our right-hand-side variables.

Since the wealth distribution is much more dispersed and rightly skewed than income, we estimate the model using median regressions. When using standard quantile regression routines available in statistical packages, we ignore the fact that households appear in the dataset more than once. This does not affect consistency of the parameter estimates. However, in the presence of unobserved individual effects, the (composite) error term is positively correlated within a household. By ignoring this positive correlation, we could underestimate the standard errors of the parameter estimates and overestimate the t-values. Therefore we compute the standard errors by using a bootstrapping technique which takes the positive within household correlation of the error terms into account (using the cluster option in the STATA bootstrap procedure).

5.1. Empirical results for wealth

Table 2 reports the estimation results for our two measures of wealth (net worth and financial wealth). Our constructed variable DSS_t^k measuring the changes in SS is normalized by dividing by permanent income. For brevity, we do not present the estimated coefficients for the demographic variables, time dummies, learning dummies, and selectivity dummies but we only report the test for their significance. In the net worth equation, the selectivity dummies are jointly significant at the 1%-level. The learning dummies are only significant at the 10%-level for financial wealth. Many demographics are highly significant in both regressions.

The estimate corresponding to our constructed SS variable is highly significant and with the expected negative sign. Thus, there is evidence that Social Security displaced private wealth. An increase in the DSS_t^k variable by Dfl 1,000 reduces net worth by Dfl 115. As explained in section 2, in case of full displacement,

we expect the coefficient of DSS_t^k to be about 1.2, while in our estimates we find a value which is significantly smaller than 1.2 (the parameter estimate is equal to 0.115 with a standard error of 0.020). As observed earlier, one reason for this result may be the effect of SS on earlier retirement, which increases the need to save, and hence attenuates the effect of SS on saving.

As in King and Dicks-Mireaux (1982), we find strong evidence for non-homotheticity; the coefficients corresponding to permanent income and to its household specific average differs significantly from zero. The same applies to the RGNPC variables. Thus, wealthy households are not simply a scaled-up version of poorer households and permanent income continues to affect wealth even after normalizing wealth by permanent income. However, our results are pretty robust to different specifications. If we were to exclude the permanent income and the RGNPC variables from the equation, the estimates of the SS variable remain significant and of similar size (compare specification III with specification I and specification IV with specification II). Further, to address the spurious regression problem, we have added again the variable *year-of-birth squared*. This variable is not statistically significant. Even excluding the permanent income and RGNPC variables do not change the results (compare specification II with specification I and specification IV with specification III). Moreover, the estimates for the other variables of interest (age and SS) are barely affected by the inclusion of this extra variable.

Do additional cohort effects remain significant after accounting for permanent income and SS? We have tested for the existence of remaining cohort effects by adding 55 cohort dummies and examined their joint significance. For net worth, these cohort dummies are not jointly significant at the 5%-level ($\chi^2_{55}=71.46$). Thus, we can meaningfully interpret the time effects and the age-net worth profiles to which we now turn.

Given that we have been able to pin down the cohort effects, we can use the estimates of the age profile in our regression to examine another important question, i.e., whether households decumulate wealth after retirement. Figure 6 displays the age-net worth profiles for different cohorts. The reference group consists of those households who lived in a time without SS (we named it “generation 0" since it is not present in our

data set). The median age-net worth profile of this generation directly follows from the estimated coefficients corresponding to the linear spline age variables. Again, we have adopted a linear spline function with 15 equally spaced knots. The estimated coefficients corresponding to these variables are jointly significant ($\chi^2_{15}=375.98$). The median age- net worth profile for generation 0 is hump-shaped; after age 65 median net worth decreases from Dfl. 200,000 to about Dfl. 130,000 at age 87 and the differences is statistically significant ($\chi^2_1=27.52$) as the life cycle model predicts.

Figure 6 also displays the age-net worth profile for the 1911 generation. This is the oldest generation in our dataset. The age-net worth profile is constructed by using the estimated coefficients from the linear age spline variables and the time path of the SS variable for this cohort. The profile for this generation is also hump-shaped, but less so than that of generation 0. The head of households in this generation was 36 years old when a first and very restricted form of SS was introduced in 1947. Consequently, until age 36, the age net worth profiles of the 1911 generation and generation 0 coincide. In 1957, the full SS legislation came into effect. Due to the introduction of and the changes in the SS legislation, the 1911 generation saved less for retirement than the generation without any SS. The level of displacement of SS can be read directly from the estimated coefficient corresponding to DSS (Table 2). Due to SS, the median household of the 1911 generation at age 65 had about Dfl 17,000 less net worth than the members of generation 0. Such is the difference at age 65 in predicted median net worth of the 1911 generation and of generation 0. After age 65, all households draw down their SS wealth. Since we have found evidence for a displacement effect of SS, the median household of the 1911 generation decumulates wealth at a slower pace than their counterparts of generation 0.

In Figure 6, we also present the age-net worth profiles for the 1935 and 1946 generations. Since the SS legislation became more generous during the 1960s and 1970s, these generations have considerable more SS wealth than the 1911 generation. As a result, they display a less hump-shaped age-net worth profiles. Compared to older generations, younger generations who live through a period where SS was always present accumulated substantially less net worth. To summarize, Figure 6 indicates that, for the four generations under

consideration, there is evidence of a decline in wealth after retirement. The decline happens at the retirement age of 65 and wealth continues to drift downward with age.

In the previous section, we allowed for education specific age-income profiles. We have also estimated net worth for each education level. When we consider *all* right hand side variables, we reject the null hypothesis that the regression coefficients are equal across education levels. However, we cannot reject the hypothesis that the age and DSS coefficients, our variables of interest, are equal across education level ($\chi^2_{48}=68.37$). If we impose these restrictions while allowing the coefficient of the other variables to be education specific, we again find evidence for a displacement effect of SS. The coefficient corresponding to DSS is equal to -0.074 (t-value: -5.11). The age net worth profiles are somewhat less hump-shaped than the ones presented in Figure 6. For the 1935 and 1946 generations, we barely find evidence for decumulation of net worth during retirement.

In the last 2 columns of Table 2, we report the results for financial wealth. Note that in this case, the null hypothesis that there no remaining cohort effects, is rejected by the data ($\chi^2_{55}=1177.71$). Strictly speaking, we cannot interpret the age-financial wealth profiles and we do not report a graph for this measure of wealth. The displacement effect of SS is smaller than in the case of total net worth. However, financial wealth represents a limited measure of accumulation and many Dutch households accumulate wealth in other assets (home equity, other real estate).

Again, we have investigated whether there is a spurious regression problem by adding the variable *year-of-birth squared* to the model (see Table 2). This variable turns out to be significant forfinancial wealth. This is in line with our finding that we have not been able to model all cohort effects in the financial wealth equation. However, the coefficient corresponding to *DSS* is barely affected by the inclusion of this variable. We therefore cautiously conclude that we have found evidence for a displacement effect between financial wealth and SS.

We use the estimates in Table 2 to simulate the effect of a complete removal of SS. Results are reported in Table 3. Mean net worth would go up by about 15% -from Dfl. 82,263 to Dfl. 95,362- and median net worth by about 36%, if SS were abolished. Financial net worth would increase by about 10% in the mean and 25% in the median (Panel a). Results are not much different using a specification which includes the variable *year-of-birth squared* (Panel b*).* Thus, we find evidence that SS displaced wealth, and the effect is sizable when we consider medians. Changes in pension and SS, currently at the center of the public policy debate in the Netherlands and other European countries, can be expected to impact the accumulation of wealth in the future.

6. Conclusion

We have examined the income and wealth holdings of different cohorts. While many explanations have been given for observed differences among cohorts, disentangling these explanations is difficult. For example, simple cohort dummies cannot distinguish between differences in preferences and differences in economic circumstances. Our strategy consists of devising indicators that can summarize the economic conditions over time. A good proxy for the differences in the income profiles of households is the level of aggregate income per capita around the time the head of the household entered the labor market. Similarly, we have devised a proxy for the changes in the SS system at the beginning of or during the working life of the head of the household.

We find that the inclusion of a measure of productivity growth in our equations for income obviates the need to include cohort dummies. Similarly, productivity growth in permanent income and changes in SS can explain all cohort effects in wealth. Thus, past economic conditions can explain why generations differ in their wealth holdings and we do not need to resort to differences in preferences or other reasons to explain the differences in wealth holdings across generations.

Obviously, there are other economic conditions that could be important for explaining the differences in wealth accumulation, including precautionary motives, longevity, changes in house prices, bequest motives,

changes in demographics and female labor supply. Undoubtedly, these factors play a role. The strategy in this paper has been, however, to simplify the model of wealth accumulation as far as possible while still being able to explain important features of the data. The fact that our two proposed economic indicators for productivity growth and SS are effective in explaining the wealth holdings of different cohorts suggests that either these other factors are very strongly correlated with our indicators, or that the other factors are of secondary importance in explaining the wealth accumulation of different cohorts.

Appendix A. Social Security and wealth holdings

The permanent income model

We start the analysis by considering the closed-form solution for wealth in the LCH-PIH. Throughout this appendix, we carry out the analysis for a single individual of age *t*. In what follows, we maintain the assumptions that preferences are quadratic and intertemporally separable and that the interest rate equals the rate of time preference. The intertemporal budget constraint is written as:

$$c_t = (1+r)A_{t-1} + y_t - A_t \tag{A.1}$$

where y_t is non-capital income at age *t*, *r* is the interest rate, A_t is wealth at the end of period *t*, c_t is consumption at age *t*. We adopt the convention that all income (both capital income and non-capital income) is received at the end of each period; the same holds for the timing of consumption.

It is rather easy to see that consumption at age *t* is equal to:[19]

$$c_t = \left(\sum_{\tau=t}^{L} (1+r)^{t-\tau} \right)^{-1} \left((1+r)A_{t-1} + \sum_{\tau=t}^{L} (1+r)^{t-\tau} E_t\, y_\tau \right) \tag{A.2}$$

where *L* is the time horizon, E_t is the expectation operator conditional upon all information available at time *t*. From (A.1) and (A.2) one can derive that wealth holding at the end of period *t* is equal to:

$$\begin{gathered} A_t = (1+r)^t A_0 + (1+r)^{t-1} y_1 + (1+r)^{t-2} E_1 y_2 + .. + E_1 y_t - \left(\frac{(1+r)^t - 1}{r} \right) Y_{pl} + \\ (1+r)^{t-2}(y_2 - E_1 y_2) + ... + (1+r)^{t-k}(y_k - E_1 y_k) + .. + (y_t - E_1 y_t) - \\ \left(\left(\frac{(1+r)^{t-1} - 1}{r} \right)(c_2 - E_1 c_2) + ... + \left(\frac{(1+r)^{t-k+1} - 1}{r} \right)(c_k - E_{k-1} c_k) + ... + (c_t - E_{t-1} c_t) \right) \end{gathered} \tag{A.3}$$

where Y_{p1} is permanent income evaluated in the first period of the life cycle, defined as:

$$Y_{pl} \equiv \left(\sum_{\tau=1}^{L} (1+r)^{1-\tau} \right)^{-1} \left((1+r)A_0 + \sum_{\tau=1}^{L} (1+r)^{1-\tau} E_1 y_\tau \right) = c_1 \tag{A.4}$$

One can verify (A.3) by inserting the expressions for A_t and A_{t-1} into the intertemporal budget constraint (A.1)

[19] We assume that someone's life cycle starts at the beginning of his/her working life. Without loss of generality, we assume that the working life starts at age 22. Strictly speaking, the index t denotes the number of years since someone's life cycle started (i.e., t=age-21).

and by using the martingale property of consumption: $c_t = E_t c_{t+1}$. The first part of (A.3) (until Y_{p1}) simply states that, in the absence of new information, wealth is equal to (expected) accumulated saving. During the life cycle, new information becomes available so that the consumer replans his/her consumption path. The remainder of the equation displays the effects of the revisions in income and the revisions in the consumption path due to the introduction and changes in SS.

The effect of the introduction of and changes in SS

Expression (A.3) can be used to highlight the effects on wealth of both the introduction of SS and later revisions in the level of SS. We consider an individual whose age is $\boldsymbol{k}$ when SS was introduced. Notice that the index $\boldsymbol{k}$ is a cohort indicator.[20] In order to compute the displacement effect of SS, we have to make some assumptions. Initially, we make three assumptions, two of which will be relaxed later on. First, we assume that after its introduction, the amount of the SS benefit does not change. Second, we assume that individuals hold static expectations concerning the future level of SS.[21] That is, they plan their consumption as if the level of SS remains constant during the course of their lifetime. Third, we assume that individuals ignore any possible feedback effect of SS on their current income (e.g. through a change in taxes). The first and last assumption will be relaxed later on.

Generations who lived their whole life in an environment without Social Security (the reference group) stick to their consumption and wealth plans that were derived at the beginning of their life cycle. For such individuals, only the first line of equation (A3) is relevant because they do not revise their income expectations and consequently do not change their consumption plan.

In our sample, we can distinguish two types of generations. The first type of generation (the older

[20] For example, the generation born in 1935 was 22 years old when SS was introduced in the Netherlands in 1957. For that generation, $\boldsymbol{k}=1$. For the 1934 generation, $\boldsymbol{k}=2$ etc..The cohort indicator $\boldsymbol{k}$ can take negative values (for generations born after 1936).

[21] Or equivalently, that shocks in SS are taken to be permanent.

generation), had already started their working career (they were older than 22) when SS was introduced, but was not retired yet, i.e., $1<k<R$ (R= retirement age). For the second type of generation (the younger generation), SS was already present when they started their working career ($k \leq 1$).

We first explain how we have computed the displacement effect of SS for the older generation. We investigate how wealth holdings at age t change due to the introduction of SS at age k. We start by considering non-retirees, i.e., $k \leq t \leq R$. Due to our assumptions presented above, pre-retirement income is not affected by the introduction of SS. Consequently, the second line of equation (A3) is not relevant for measuring the effect of SS on pre-retirement wealth holdings. Looking at the third line of equation (A.3) only the following term is relevant:

$$-\frac{(1+r)^{t-k+1}-1}{r}\left(c_k - E_{k-1}c_k\right), \quad t=k,\ldots,L \tag{A.5}$$

Due to the introduction of SS at age k, from that date onwards consumption is shifted upwards permanently. Equation (A.5) says that the effect of SS on consumption ($c_k - E_{k-1}c_k$) should be compounded until age t in order to assess the effect of SS on wealth holdings. The upward shift in consumption is equal to the discounted sum of SS benefits (discounted back to period k) times the marginal propensity to consume out of lifetime income:

$$c_k - E_{k-1}c_k = \left(\sum_{\tau=k}^{L}(1+r)^{k-\tau}\right)^{-1}\left(\sum_{\tau=R+1}^{L}(1+r)^{k-\tau}SS\right) = (1+r)^{k-R-1}\cdot\frac{1-(1+r)^{R-L}}{1-(1+r)^{k-L-1}}\cdot SS, \quad t=k,..,L \tag{A.6}$$

where SS measures the size of SS-benefits. From equation (A.6), it follows that the older the individual was when SS is introduced (i.e., the bigger k), the more he/she shifts upwards her consumption profile (see also Figure 1). Substitution of equation (A.6) into (A.5) gives the displacement effect, DSS_t^k on wealth holdings for people who are not retired yet:

$$DSS_t^k = -\left(\frac{(1+r)^{t-k+1}-1}{(1+r)^{L-k+1}-1}\right)\left(\frac{(1+r)^{L-R}-1}{r}\right)SS, \quad for \ 1<k\leq t\leq R \tag{A.7}$$

Notice that we have two indices (t and k) capturing that the introduction of SS causes an interaction of age (t) and cohort (k) effects on wealth holdings (see again Figure 1).

We now investigate how wealth of generation k is affected by SS ($t>R$) if individuals are already retired. There are two effects as can be seen from equation (A.3). First, wealth is adjusted downwards because of the increase in consumption . Second, due to the introduction of SS, retirement income of generation k also increased (see the second line of equation (A.3)) which has the following effect on wealth holdings:

$$(1+r)^{t-(R+1)}(y_{R+1}-E_1y_{R+1})+..+(y_t-E_1y_t)=SS\sum_{\tau=R+1}^{t}(1+r)^{t-\tau}=\frac{(1+r)^{t-R}-1}{r}SS, \quad t=R+1,...,L, \ 1<k\leq R \tag{A.8}$$

The total effect of the introduction of SS at age k on wealth for people who are retired is therefore the sum of expressions (A.7) and (A.8):

$$DSS_t^k = -\left(\frac{(1+r)^{L-R}}{r}\right).\left[1-(1+r)^{t-L}\right]\left(\frac{(1+r)^{R-k+1}-1}{(1+r)^{L-k+1}-1}\right)SS, \ 1<k\leq R<t\leq L \tag{A.9}$$

To summarize, equations (A.7) and (A.9) describe the displacement effect between SS and private wealth at age *t* for the first type of generation (the old generation).

However, for many households in our sample (i.e., for those for which $k\leq 1$), SS was already in place when they started working. Again we can use equation (A.3) to compare the wealth holdings of these "young generation" households with those who lived in times without SS. In this case, only the tem Y_{pl} is affected; it is shifted upwards as follows (see equation (A.4)):

$$\left(\sum_{\tau=1}^{L}(1+r)^{1-\tau}\right)^{-1}\left(\sum_{\tau=L_1+1}^{L}(1+r)^{1-\tau}SS\right) = (1+r)^{-L_1}.\frac{1-(1+r)^{L_1-L}}{1-(1+r)^{-L}}.SS \tag{A.6'}$$

Notice that expressions (A.6') and (A.6) are rather similar. In the case of the young generations ($k\leq 1$), for those who are not retired yet the displacement effect of SS on wealth becomes:

$$DSS_t^k = -\left(\frac{(1+r)^t-1}{(1+r)^L-1}\right)\left(\frac{(1+r)^{L-R}-1}{r}\right)SS, \quad for\ 1\le t\le R,\ k\le 1 \tag{A.7'}$$

and for those who are already retired[22]

$$DSS_t^k = -\left(\frac{(1+r)^{L-R}}{r}\right).\left[1-(1+r)^{t-L}\right]\left(\frac{(1+r)^R-1}{(1+r)^L-1}\right)SS,\ R<t\le L,\ k\le 1 \tag{A.9'}$$

Up to now, we have assumed that after its introduction, the amount of the SS-benefit is not revised by the government. Obviously, this assumption is not realistic but it can easily be relaxed. In our notation we should now allow for the fact that the SS benefit is age and cohort specific; let SS_t^k be the SS-level prevailing at age t for generation k. First, we examine how wealth is affected by the introduction of and revisions in SS for those who are not retired yet. For the "old" generation (born before 1935 for which $k>1$), only the consumption innovations ($c_l - E_{l-1}c_l$) dated later than k are affected by revisions in SS (see last line of equation (A.3)). For the "young" generation (for which $k\le 1$), all consumption innovations in (A.3) should be considered. We can combine the two types of generations by using an index m which is equal to k for the old generation and to 1 for the young generation. The consumption innovation at time l can be expressed as a function of the revisions in SS as follows:

$$\begin{aligned} c_l - E_{l-1}c_l = \left(\sum_{\tau=l}^{L}(1+r)^{l-\tau}\right)^{-1}\left(\sum_{\tau=R+1}^{L}(1+r)^{l-\tau}SS_l^{k*}\right) = \\ (1+r)^{l-R-1}.\frac{1-(1+r)^{R-L}}{1-(1+r)^{l-L-1}}.SS_l^{k*},\ l=m+1,..,L \end{aligned} \tag{A.10}$$

where $SS_l^{k*}=SS_l^k-SS_{l-1}^k, l=m+1,...,L$ denotes the revision in SS. Combining equations (A.3), (A.7) ((A.7')) and (A.10), we arrive at the following displacement effect of SS on wealth for non-retirees:

[22]We consider this case even thought we do not have any of these households in our sample.

$$DSS_t^k = -\sum_{l=m}^{t}\left(\frac{(1+r)^{t-l+1}-1}{(1+r)^{R+1}-1}\right)\left(\frac{(1+r)^{L-R}-1}{r}\right)SS_l^{k*},\quad for\ m\le t\le R \tag{A.11}$$

where $SS_m^{k*}=SS_m^k$. The displacement effect for retirees can be derived in a similar way. Again, it should be noted that in equation (A.3) apart from the consumption revisions, the revisions in retirement income should be also taken into account. The displacement effect is as follows:

$$DSS_t^k = -\left(\frac{(1+r)^{L-R}}{r}\right).\left[1-(1+r)^{t-L}\right]\sum_{l=m}^{R}\left(\frac{(1+r)^{R-l+1}-1}{(1+r)^{L-l+1}-1}\right)SS_l^{k*},\ m\le R<t\le L \tag{A.12}$$

In the derivation of equation (A.12) we have made use of the fact that any change in SS after retirement is considered to be permanent by the individual, and hence translates into a corresponding change in consumption. As a result, saving does not change and thus wealth holdings after retirement are not affected by changes in SS that take place after retirement.

Let us now relax the assumption that the introduction of SS does not affect the income of the working population. Instead we assume that, corresponding to a given level *SS*, a payroll tax is levied equal to αSS. For simplicity, we take α to be a constant. This would, for instance, correspond to a stationary population and a strict pay-as-you-go system. In that case α is equal to the ratio of the number of SS recipients to the number of workers. It can be shown that the effect of the payroll tax on wealth accumulation is equal to α times the expressions (A.11) and (A.12). This follows directly from the certainty equivalent set-up. Under the assumptions made, consumption is constant across the life cycle. Given the age of retirement, saving during the working life is simply a function of the difference in incomes between retirement and the working life. An increase in income during retirement therefore has the same effect as a reduction in income during the working life. The total effect of SS (including the effect of the payroll tax) is equal to ß = $(1+\alpha)$ times expressions (A.11) and (A.12). In our empirical work, we compute (A.11) and (A.12) for all possible ages t and for all generations which we observe in our sample. A generalization to the case where the payroll tax varies across age is straightforward. The factor ß is replaced by $ß_k$ and moved under the summation sign.

Appendix B. Construction of permanent income measures

To construct permanent income, we use the estimated income equations to predict future non-capital incomes of all households in the sample. Permanent income at age t is equal to (suppressing the household index h):

$$Y_{pt} = B_t^{-1} \sum_{\tau=t}^{L} (1+r)^{t-\tau} E_t y_\tau \tag{B.1}$$

with

$$B_t \equiv \sum_{\tau=1}^{L} (1+r)^{t-\tau} = \frac{(1+r)[1-(1+r)^{t-(L+1)}]}{r} \tag{B.2}$$

The expression for $E_t y_\tau$ follows from (6) and (7), under the additional assumption that the error term ϵ_{th} is normally distributed. We consider two cases.

The first case is where all right hand side variables are assumed to remain constant as of age t, except age. We can then write (6) and (7) as:

$$\ln(y_\tau) = X_t + f(\tau) + \epsilon_\tau \tag{B.3}$$

where $f(\tau)$ is the age function and X_t represents the influence of all other explanatory variables (including the individual effect). The expression for expected future incomes then becomes:

$$E_t y_\tau = \exp[X_t + f(\tau) + \frac{1}{2}\sigma_\epsilon^2] \tag{B.4}$$

Inserting this expression into (B.1) yields the permanent income variable to be used in the explanation of household wealth.

The second case arises if we drop the assumption that the right hand side variables of the income equation will remain constant if one grows older. In particular, family composition may change in predictable ways. Thus, in the second case, we estimate an auxiliary equation which predicts household composition when age increases. This prediction is next used on the right hand side of the income equation to update X_t when the

household ages. Equation (B.4) is now replaced by

$$E_t y_\tau = \exp[X_\tau + f(\tau) + \frac{1}{2}\sigma_\epsilon^2] \tag{B.5}$$

In the empirical section of this paper we predict future income using equation (B.5). We have, however, experimented with using equation (B.4) instead of (B.5). The results are not affected by this choice.

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Table 1: Estimation results for income, by education level Dependent variable is logarithm of non-capital income				
	Educ level 1	Educ level 2	Educ level 3	Educ level 4
rgnpc1	0.070 (0.069)	0.058 (0.083)	0.059 (0.073)	0.107 (0.098)
rgnpc2	-0.082 (0.043)	-0.034 (0.052)	-0.037 (0.047)	-0.102 (0.064)
rgnpc3	0.011 (0.005)*	0.005 (0.006)	0.005 (0.005)	0.012 (0.007)
Number of observations	11,479	9,084	18,427	1,2401
Number of households	1,922	1,484	2,782	2,012
Log likelihood	-4,314.81	-3,180.22	-3,923.71	-5,057.91
p-value χ^2-test joint significance RGNPC coefficients	0.001	0.000	0.000	0.136
p-value χ^2-test joint significance age-spline coefficients	0.000	0.000	0.000	0.000
p-value χ^2-test gainst a model with a full set of age dummies	0.312	0.070	0.350	0.325
p-value χ^2-test joint significance time dummies	0.211	0.239	0.214	0.014
p-value χ^2-test joint significance learning dummies	0.601	0.118	0.000	0.308
p-value χ^2-test joint significance selectivity dummies	0.627	0.767	0.109	0.307
p-value test against a model with a full set of cohort dummies	0.655	0.08	0.879	0.387
*indicates significance at 5% level; ** indicates significance at 1% level				

Note: This table reports the estimates of the productivity growth variables in the income regression. Estimation is performed separately by education level. Standard errors are reported in parentheses. For brevity, estimates of other variables are not reported, but the table reports tests of their joint significance. Refer to Section 4 for a complete list of the variables included in the regressions.

Table 2: Estimation results for net worth and financial net worth. Dependent variable is wealth divided by permanent income								
	Net worth				Financial wealth			
	Spec. I	Spec. II	Spec. III	Spec. IV	Spec. I	Spec. II	Spec. III	Spec. IV
DSS	-0.115	-0.108	-0.101	-0.088	-0.020	-0.018	-0.022	-0.019
	(0.020)**	(0.021)**	(0.018)**	(0.018)**	(0.006)**	(0.005)**	(0.005)**	(0.005)**
rgnpc1	0.155	0.138			-0.008	-0.041		
	(0.218)	(0.226)			(0.060)	(0.062)		
rgnpc2	-0.004	-0.003			0.016	0.015		
	(0.123)	(0.125)			(0.038)	(0.038)		
rgnpc3	0.001	0.001			-0.002	-0.001		
	(0.013)	(0.013)			(0.44)	(0.004)		
Permanent income	-0.277	-0.262			-0.059	-0.052		
	(0.098)**	(0.097)**			(0.023)*	(0.023)*		
Permanent income (household specific average)	0.851	0.829			0.162	0.153		
	(0.114)**	(0.118)**			(0.027)**	(0.027)**		
year-of-birth^2/1000		-0.136		-0.441		-0.285		-0.272
		(0.082)		(0.165)*		(0.054)**		(0.048)**
Number of observations	41,105	41,105	41,105	41,105	41,057	41,057	41,057	41,057
p-value χ^2-test H_0: $\beta_{DSS}=0$; $\beta_{MDSS}=0$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p-value χ^2-test H_0: $\beta_{rgnpc1}=\beta_{rgnpc2}=\beta_{rgnpc3}=0$	0.000	0.001			0.167	0.492		
p-value χ^2-test joint significance time dummies	0.000	0.000	0.000	0.000	0.022	0.000	0.005	0.000
p-value χ^2-test joint significance selectivity dummies	0.000	0.000	0.000	0.000	0.083	0.509	0.152	0.770
p-value χ^2-test joint significance learning dummies	0.146	0.096	0.191	0.304	0.091	0.059	0.047	0.067
p-value χ^2-test joint significance agespline variables	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p-value test against a model with a full set of cohort dummies	0.067				0.000			
* indicates significance at 5% level; ** indicates significance at 1% level								

Note: This table reports the estimates of variables measuring productivity growth and Social Security in the wealth regressions. The model is estimated using median regressions (standard errors are in parentheses). For brevity, estimates of other variables are not reported, but the table reports tests of their joint significance. Refer to Section 5 for a complete list of the variables included in the regressions.

Table 3a: The effects of Social Security on wealth (specifications I and II)				
Main model	Net Worth (mean)	Net Worth (median)	Financial Wealth (mean)	Financial Wealth (median)
Sample	82263	35346	21292	6800
Without SS	95362	48206	23619	9083
Main model with year-of-birth^2				
Sample	82263	35346	21292	6800
Without SS	94544	47350	23319	8790

Table 3b: The effects of Social Security on wealth (specifications III and IV)				
Main model	Net Worth (mean)	Net Worth (median)	Financial Wealth (mean)	Financial Wealth (median)
Sample	82263	35346	21292	6800
Without SS	93815	46666	23842	9311
Main model with year-of-birth^2				
Sample	82263	35346	21292	6800
Without SS	92346	45101	23523	8982

Note: These tables report estimates of mean and median wealth holdings in the sample if SS were removed. In Table 3a, estimates for wealth are obtained using specifications I and II reported in Table 2, while in Table 3b, specifications III and IV are used.

Figure 1a: The effect of the introduction of Social Security on consumption

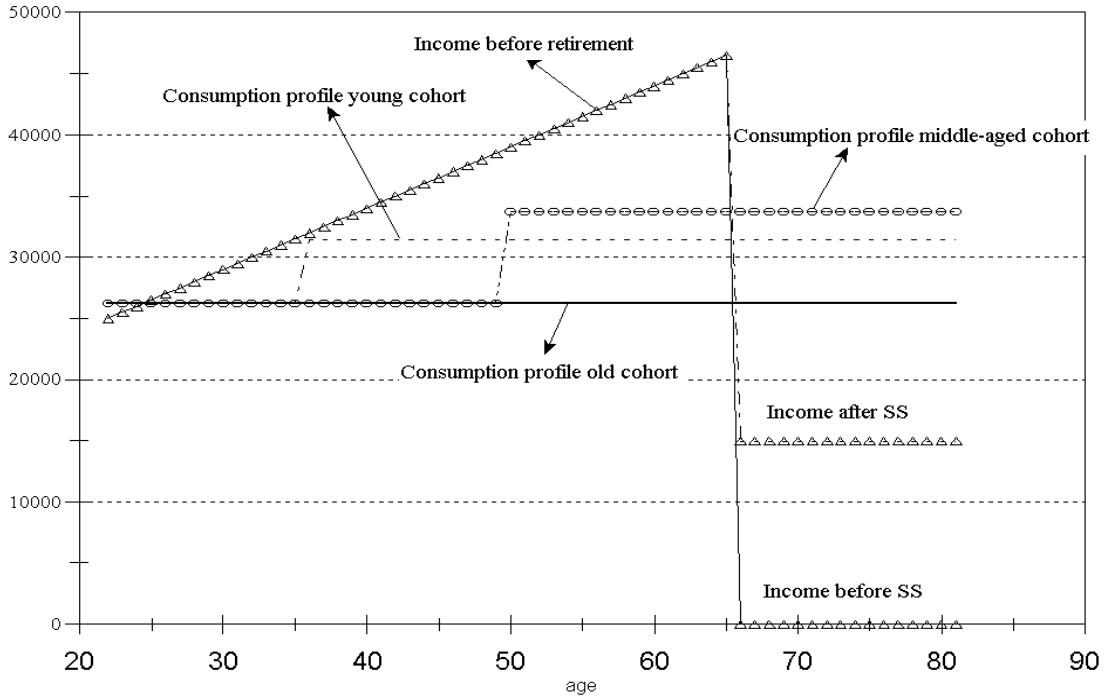
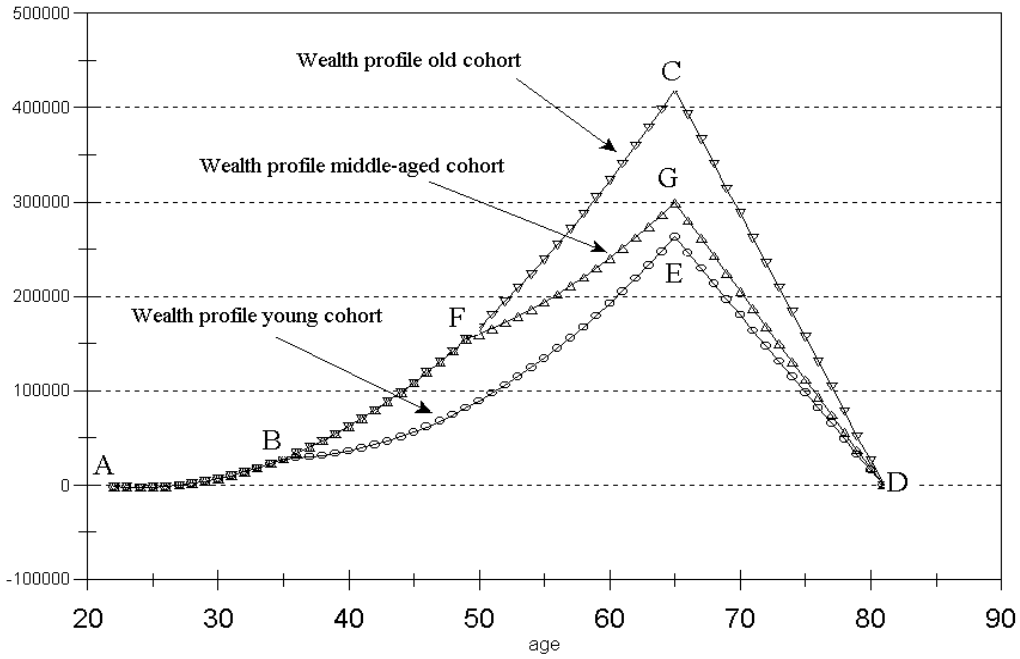


Figure 1b: The effect of the introduction of Social Security on wealth



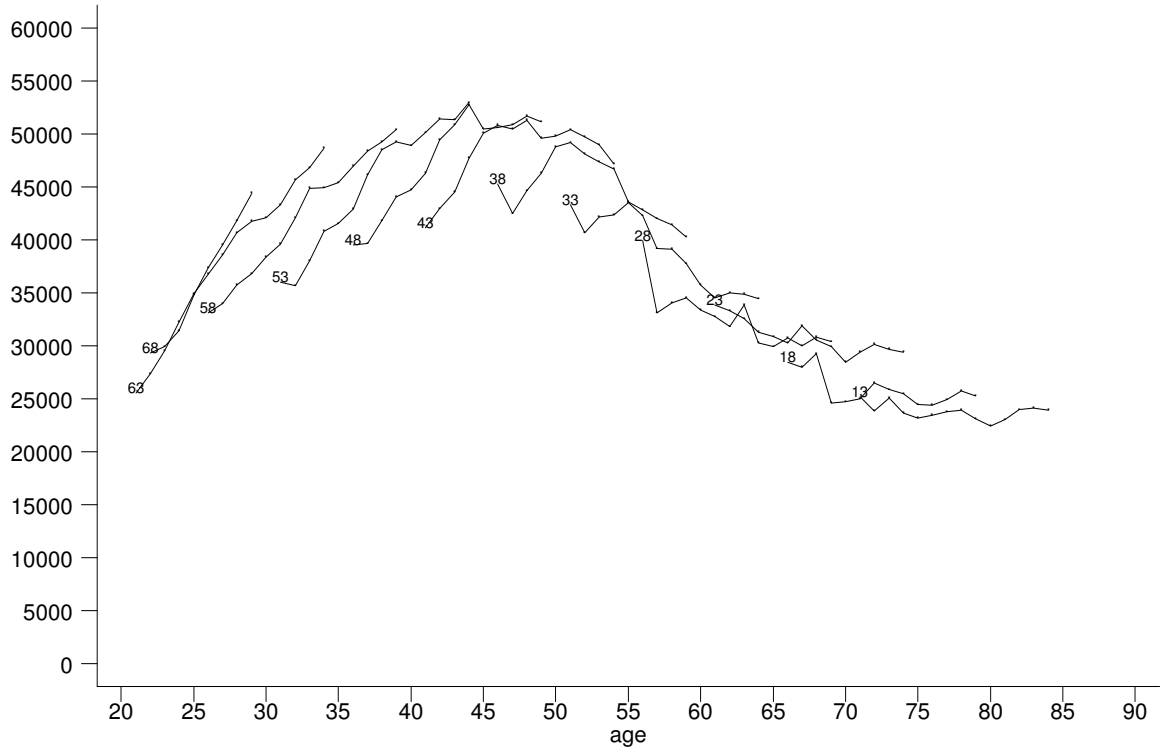


Figure 2: Average non capital income by age and cohort

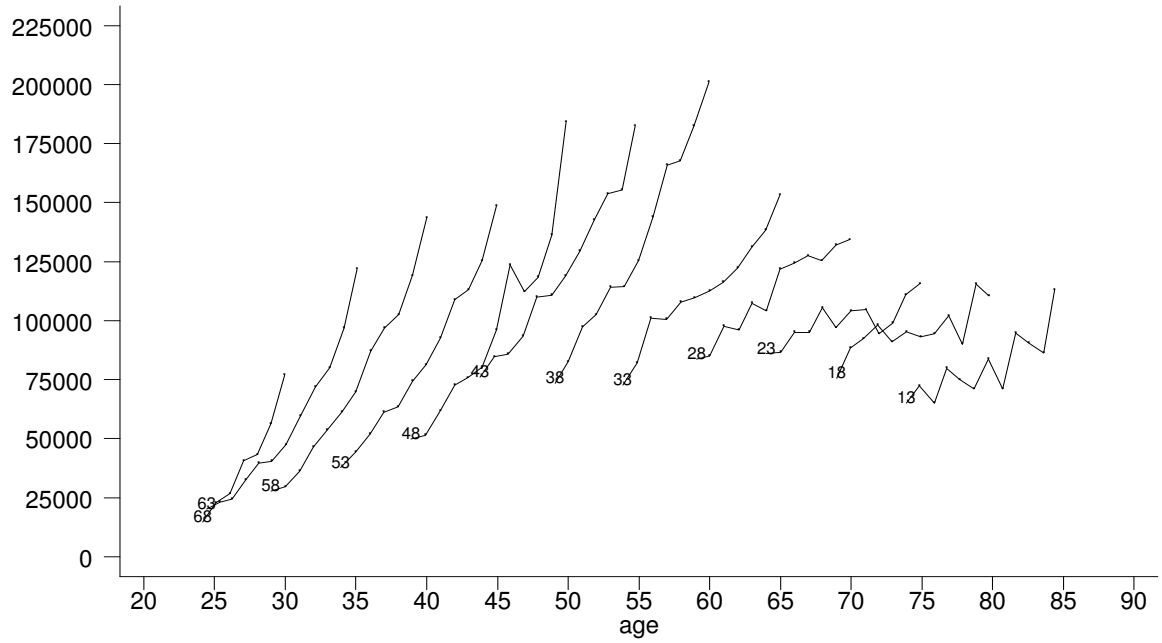


Figure 3a: Average net worth by age and cohort

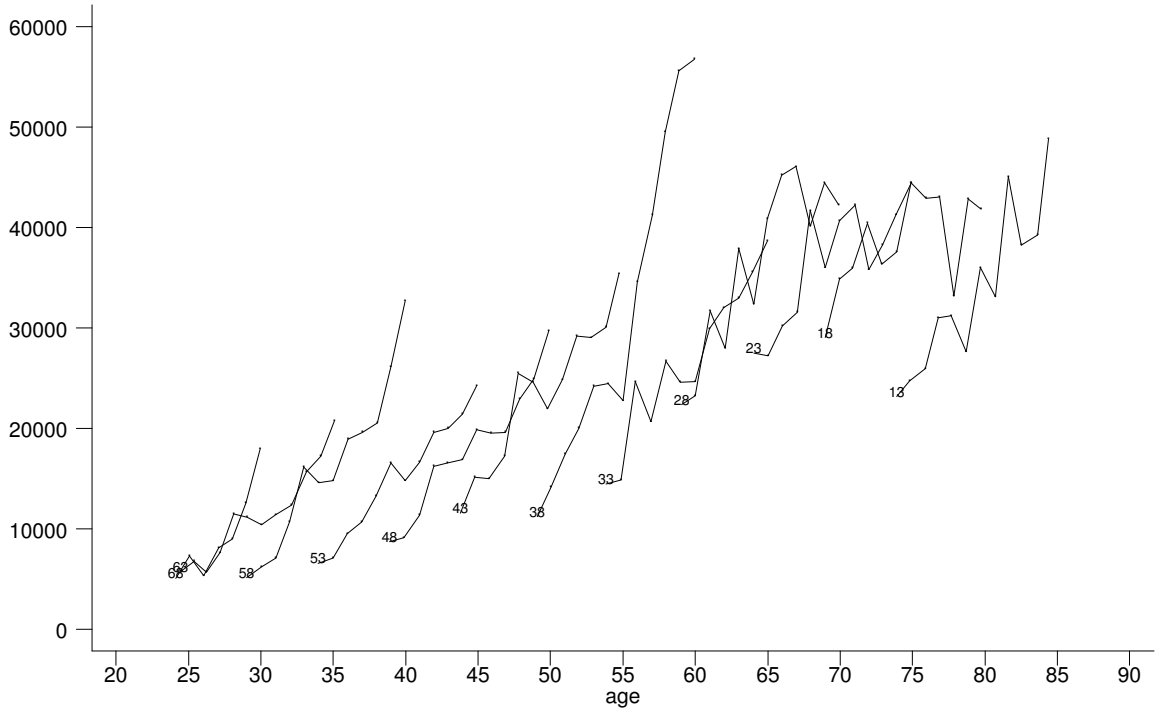


Figure 3b: Average financial wealth by age and cohort

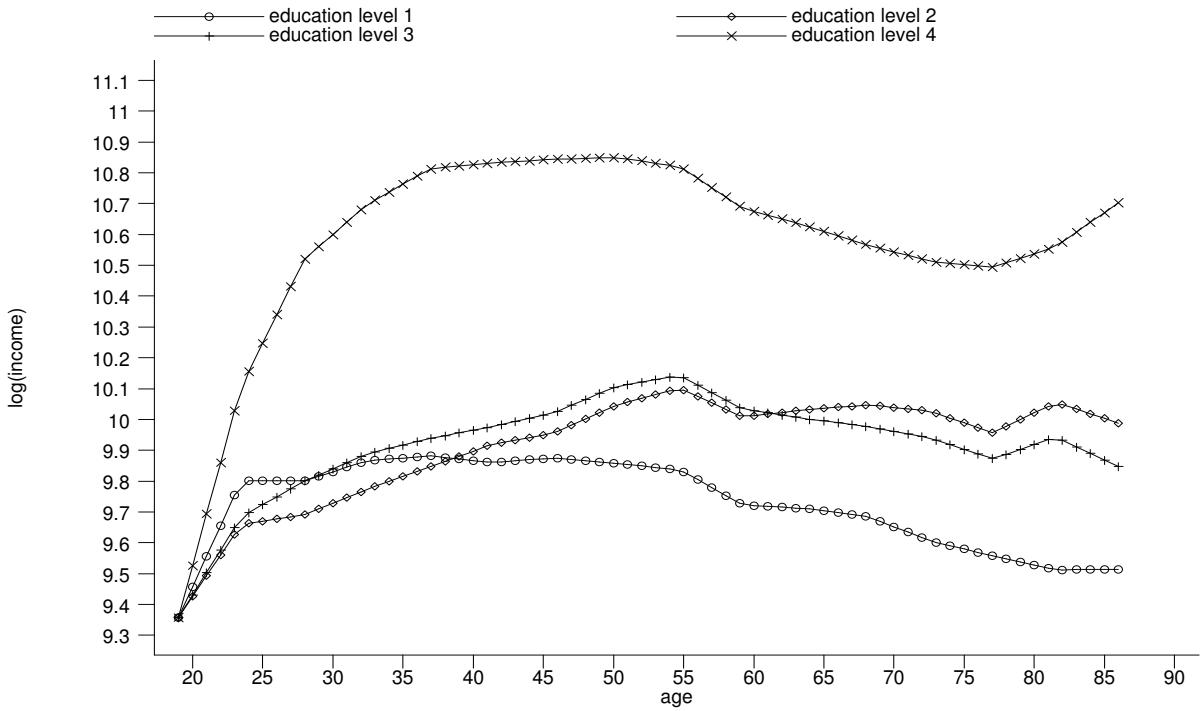


Figure 4: Education specific age-log(income) profiles

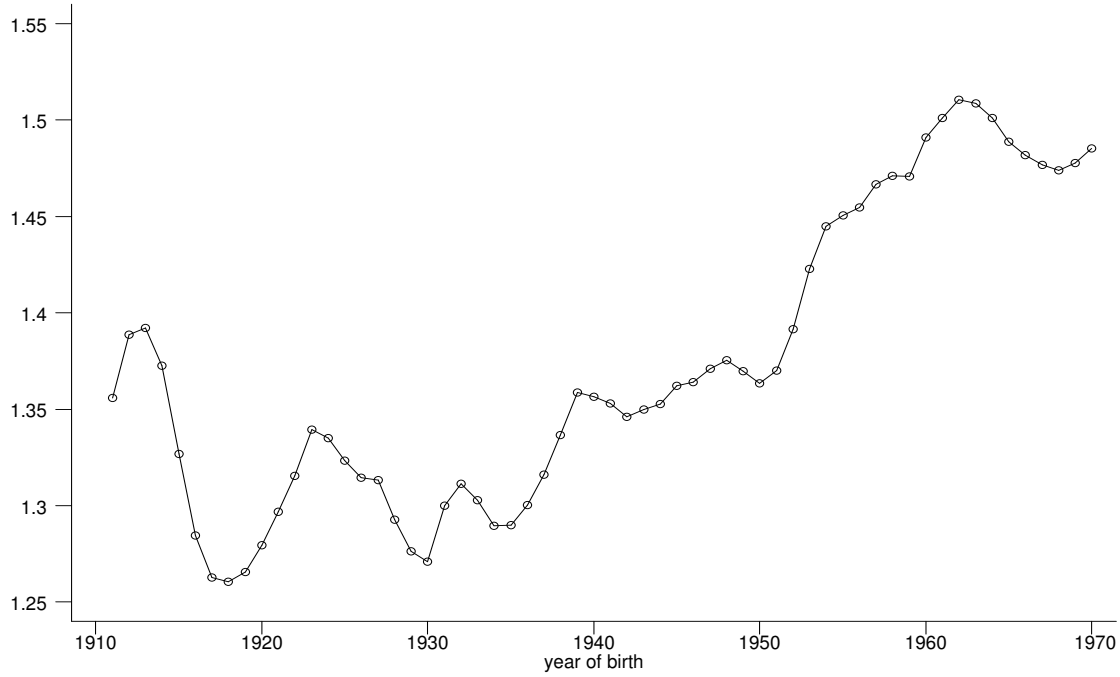


Figure 5: Productivity of different cohorts for household heads with primary education

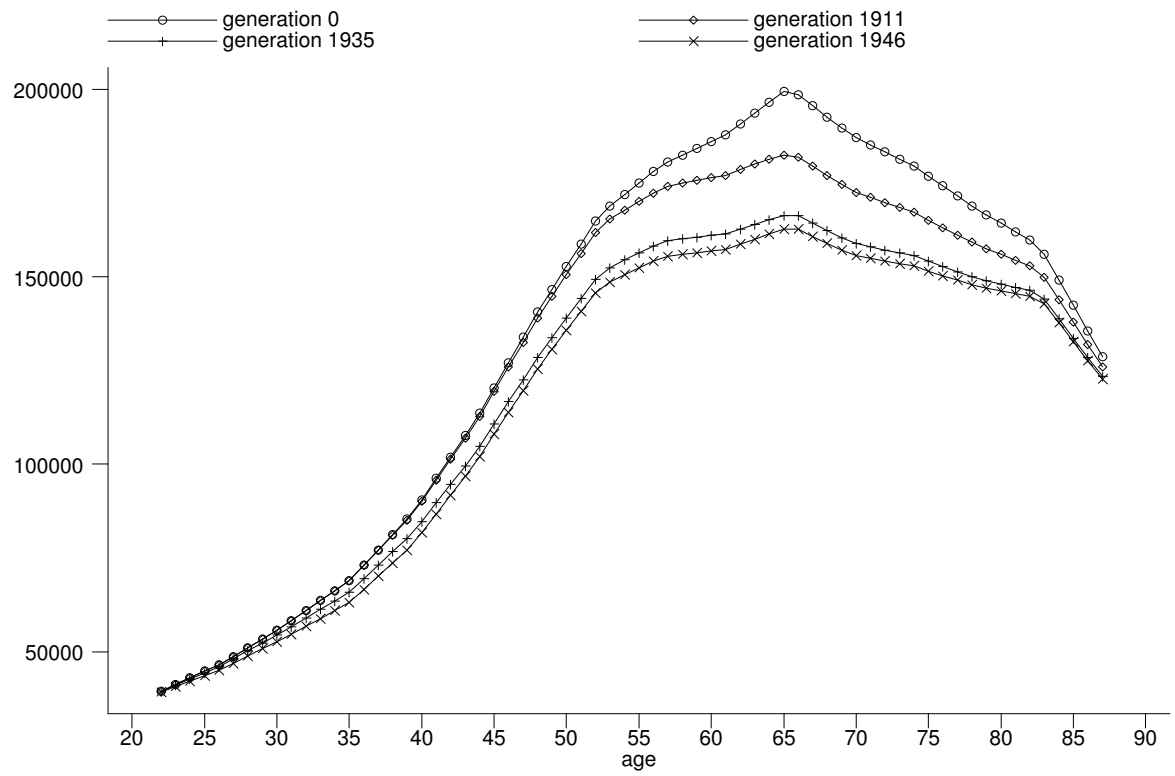


Figure 6: Age net worth profiles for different cohorts