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A Cohort Analysis of Household Saving in Norway

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October, 2002

Abstract

In this paper I study the role of generational differences in saving. My main evidence is an empirical analysis based on Norwegian data that show a tendency for older birth cohorts to have higher saving rates, but that the differences are small and statistically insignificant. Consequently, the high aggregate saving rate and the very high saving among the elderly cannot be primarily attributed to cohort effects. To ensure that the findings are robust, a variety of econometric specifications and techniques are employed.

1 Introduction

The aggregate saving rate is an important economic indicator. When policy makers make predictions about the saving rate they usually base their arguments on some macroeconomic variables and, as an implication of the lifecycle theory, the age structure of the population. Lately the role of generational differences has also been an issue in these predictions. In Norway, the general opinion is that even though saving is expected to rise when the baby-boom generations come into the high-saving phase of the lifecycle, this effect will be muffled by the fact that younger generations save less than older generations have done. In the US, it is the generations born in the 1920s and 1930s that are believed to have a lower saving propensity than other generations. These opinions seem to prevail, even though there is little support in the economic literature in favor of the hypothesis that there are generational differences in saving.

Generally, in response to the original contribution of Shorrocks (1975), attempts to separate the effects of age, period and birth cohort has proved useful in micro-studies of income, consumption, and wealth. Shorrocks showed that in the

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presence of generational differences, it is impossible to determine whether cross-section evidence provide a corresponding pattern for the lifecycle or whether it is the result of observing different generations at different points in time. As would be expected from simple lifecycle theory, the main factor determining cohort effects in these studies has been differences in productivity growth in the lifetimes of cohorts (see for example Deaton and Paxton, 1994, Kapteyn et al., 1999), although many authors also stress the role of generational differences in mortality and in preferences. Among these, Kapteyn et al. (1999) and Jappelli (1999) try to distinguish between alternative hypotheses that explain cohort effects in wealth, such as mortality rates, expectations about pension benefits, and historical productivity growth. Also, a few influential contributions (Boskin and Lau, 1988, Attanasio, 1994, 1998) have claimed to find cohort effects in saving. Attanasio (1998) claims that the cohorts born between 1920 and 1944 are those mainly responsible for the decline in the aggregate saving rate in the US in the 1980s. However, when Attanasio and Paiella (2001) used the same data with the addition of three extra years of observation this effect disappeared, a finding that is given little weight by the authors.

In this paper I argue that the role of generational differences in saving is exaggerated. Intuitively, it is not obvious that we will find cohort effects due to productivity in saving rates. Saving is either defined as the first difference in wealth, or as non-consumed income. Given that productivity is assumed to affect income, consumption, and wealth more or less equally, saving rates should not display any differences due to growth. So, if we do find cohort effects in saving, this might serve as an indicator of generational differences in preferences and attitudes. One such commonplace statement is that generations that have experienced depressions or wars tend to be more prudent or more patient. However, within the framework of a life-cycle model, a generation that is characterized as being particularly patient or prudent will save more while young and less while old, a result that goes against the intuition that the current old save much because they belong to a generation with preferences for high saving. My main evidence is an empirical analysis based on Norwegian data that show a tendency for older cohorts to have higher saving rates, but that the differences are small and the estimates statistically insignificant. To ensure that the findings are robust, a variety of econometric specifications and techniques are employed. This is opposed to the works of Attanasio et al., in which there is very little information about the robustness of the results.

The paper is organized as follows: Section 2 presents an extended life-cycle/permanent income model with uncertain income. Also presented are the comparative static effects on saving of changes in factors such as the time preference rate, the mortality rate, the risk aversion parameters and the assumed income variance. This serves the purpose of identifying potential cohort-effects in a traditional model as differences in preferences or mortality. In section 3 I give a brief description of the data, while section 4 reports the model specification, the parameter estimates and the fit of the econometric model, as well as a discussion of the robustness of the results. A conclusion is then drawn in section 5.

2 Model

The standard consumption function posits a linear relationship between consumption and "permanent income", defined as the annuity value of the sum of nonhuman wealth and the present discounted value of expected future income. Under uncertainty, the assumption of a quadratic utility function, which implies no risk aversion, yields a consumption function equal to what it would be under no uncertainty. This is the smoothing solution, commonly referred to as the life-cycle or permanent income hypothesis, and is the consumption function that is routinely used in the literature (Browning and Lusardi, 1996). When consumption is proportional to the expected present value of lifetime resources, then savings will be positive when current income is above permanent income and negative when current income is below. As such, the life-cycle hypothesis implies that households will accumulate wealth by saving during most of their working years and then dissave in retirement.

For the purpose of this paper we will need a model that allows for precautionary saving, one in which the third derivative of the utility function is positive. Hence, I consider a life-cycle model with a utility function with constant absolute risk aversion (CARA) and stochastic income. Given these assumptions it is possible to obtain a closed-form solution to the problem (see Kimball and Mankiw, 1989, Caballero, 1991, Irvine and Wang, 2001). There are two stages in life: work and retirement. The variable T is the retirement date, after which earnings are lower and less volatile. Some uncertainty about longevity is also introduced through a positive probability $(1-p)$ of accidental death in each period before reaching a maximum age $(T+N)$, after which one dies a natural death.

A representative agent maximizes the discounted sum of expected future utility

$$V(A_0) = \max E_0 \sum_{t=1}^{T+N} -\frac{1}{\theta} e^{-\theta C_t} \left(\frac{p}{1+\delta} \right)^t \tag{1}$$

subject to an accumulation constraint

$$A_t = (1+r) A_{t-1} - C_t + Y_t, \quad t = 1, ..., T+N \tag{2}$$

$$A_{T+N} \geq 0, \quad \text{given } A_0 \tag{3}$$

where E_t is the expectation operator conditional on information available at time t, θ is the coefficient of absolute risk aversion, C_t is consumption and Y_t is income, A_t is the non-human wealth, r is the interest rate, and δ is the rate of time preference.

The income process is described by

$$Y_t = \begin{cases} Y_0 + \xi_t, & 1 \leq t \leq T \\ \alpha Y_0 + \xi_t, & T < t \leq T+N \end{cases}$$

where it is assumed that $0 < \alpha < 1$, and that $\{\xi_t\}_{t=0}^{T+N}$ is a random walk defined by

$$\xi_{t+1} = \xi_t + \varepsilon_{t+1}$$

with $\xi_0 = 0$ and $\{\xi_t\}_{t=0}^{T+N}$ normally and independently distributed

$$\begin{aligned} \varepsilon_t &\sim N\left(0, \sigma_1^2\right) \quad \text{for } 1 \leq t \leq T \\ \varepsilon_t &\sim N\left(0, \sigma_2^2\right) \quad \text{for } T < t \leq T+N \end{aligned}$$

Thus, there is a decline in expected income at the time of retirement, and also a reduction in the expected income variance, since I assume that $\sigma_2^2 < \sigma_1^2$.

The model is based on the results in Caballero (1990) who showed that when the instantaneous utility function is exponential, the return on assets is certain, and income follows an ARMA process, then we can use the result that the disturbance of the stochastic process of consumption is equal to the annuity value of the innovation in income. Moreover, the exposition follows closely that of Irvine and Wang (2001), but differs in the description of the income process with the inclusion of the replacement ratio α.

2.1 The optimal solution

We can solve the problem in (1) with respect to optimal consumption using dynamic programming and the result of Caballero (1990). The maximization gives the consumption function

$$\begin{aligned} C_t &= Y_t - Y_0 + K + \gamma_1 (t - T) + \gamma_2 (T - \bar{t}), \quad && 1 \leq t \leq T \\ C_t &= Y_t - \alpha Y_0 + K + \gamma_2 (t - \bar{t}), && T < t \leq T+N \end{aligned} \tag{4}$$

where the following notation is used

$$R = \frac{1}{1+r},$$

$$K = \frac{1}{1-R^{T+N}} \left[\begin{array}{c} rA_0 + \left(1 - R^T\right) Y_0 + R^T \left(1 - R^N\right) \alpha Y_0 \\ + \left(T - \frac{1-R^T}{1-R}\right) (\gamma_1 - \gamma_2) \end{array} \right],$$

$$\bar{t} = \frac{1}{1-R} - \frac{(T+N) R^{T+N}}{1-R^{T+N}},$$

and

$$\gamma_i = \frac{1}{2}\theta\sigma_i^2 + \frac{1}{\theta} \ln\left(\frac{p(1+r)}{1+\delta}\right), \quad i = 1, 2$$

where γ is called the consumption path's slope. Consumption in this model is stochastic as it follows the process of income, with the agent increasing his consumption when $Y_t > Y_0$ and reducing his consumption when $Y_t < Y_0$. Furthermore, consumption is proportional to the expected present value of lifetime resources which consists of non-human wealth (A_0) and the present discounted value as of time t of expected future labor income, expressed by the three first terms in the bracket of K. The fourth term is the contribution of the precautionary motive, given the random walk. When γ_i is negative and $\sigma_2^2 < \sigma_1^2$, its contribution is to reduce the level of consumption.

The consumption path's slope, γ_i, is determined by uncertainty on the one hand, and the ratio between the discount rate and the interest rate on the other hand. Uncertainty is represented by the degree of risk aversion and variation in expected income, and will generally have a positive effect on the age-slope. Uncertainty induces consumers to postpone consumption and therefore tilt the consumption trajectory down early in life. This generates additional consumption growth. When the discount rate is greater than the interest rate, $r < \delta$, the consumer prefers to consume today instead of postponing his consumption, thus exhibiting a kind of impatience. The second term of γ_i is negative when $r < \delta$, and for all commonly used parameter values in γ_i this negative term is greater than the first positive term. Since I have assumed no trend in the income process, when γ_i is negative, consumption will be decreasing with age.

After retirement there is a downward shift due to the decline in expected income, and there is a negative shift in the age-consumption slope as well since $\gamma_2 < \gamma_1$ when $\sigma_2^2 < \sigma_1^2$. The former is in line with the general empirical finding that consumption drops at retirement. This drop can be explained as the absence of work-related expenditures (see Banks et al., 1998, for a further discussion). We observe that $\bar{t}$ represents a kind of "tilt-point" for the consumption path. Another interpretation is a kind of subjective "mid-age" that will depend on the size of the discount factor. If the working period is 45 years and the retirement period is at most 20 years, then the maximum life-span is $T + N = 45 + 20 = 65$. Assume also an interest rate $r = 0.03$. This gives us an approximate value of 23 for the tilt-point $\bar{t}$, corresponding to the actual age of 43 years old.

The optimal solution for saving defined as non-consumed labor income, $S_t \equiv Y_t - C_t$, is easily derived from (4)

$$
\begin{aligned}
S_t &= Y_0 - K - \gamma_1 (t - T) - \gamma_2 (T - \bar{t}), \qquad && 1 \leq t \leq T \\
S_t &= \alpha Y_0 - K - \gamma_2 (t - \bar{t}), && T < t \leq T + N
\end{aligned} \tag{5}
$$

The model describes an impatient consumer who will prefer more consumption today rather than deferring consumption to the future. Saving grows with a factor $-\gamma_1 > 0$ over the life-cycle until retirement age, then shifting down with the drop in income $(1 - \alpha) Y_0$ at retirement, and continuing to grow with a factor $-\gamma_2 > 0$ in retirement. Whether saving is positive, negative, or both in retirement depends on the values used in the analysis. Saving continues to grow in retirement because the agent is still impatient, preferring perhaps not to reduce consumption as much as the drop in income should imply. It is a special feature of the model that consumption is stochastic, but the implication that consumption decreases and saving grows over the life cycle is a straightforward consequence of the assumption that $r < \delta$.

Assuming that the per-period survival rate is constant is an obvious simplification, but letting p decrease with age would only result in overall lower saving and not change the main results. This follows from (5) since the savings function describes the optimal solution and expected saving seen from the initial period.

2.2 Cohort specific saving

If there are generational differences in saving, or so-called cohort effects, this would be because consumers born in different time periods have different paths for saving. Unless it is a characteristic that a cohort is born with, such differences will be due to a cohort being a certain age at a certain time. For example, a popular notion is that older generations may be thriftier and more alert to risk than younger generations. Since the model assumes that preferences are given over the life-cycle, this kind of reasoning implicitly assumes that preferences are shaped during a cohort's so-called "formation years". This could be the period in which they enter the labor market and form a household.

2.2.1 Life expectancy

As is known from demography, older cohorts may have a higher probability of death (lower per period survival probability p) than younger cohorts due to debilitation effects (see for instance Hobcraft et al., 1982). When younger generations may have a higher probability of surviving each period, they will expect to live longer than previous generations, so that this is analogous to an increase in expected longevity. Assuming cohort specific mortality gives the general result that cohorts with a higher per period survival probability will consume less early in life and have more rapid consumption growth over the life cycle than cohorts with lower survival probability. From (5) we find that

$$\frac{\partial S_t}{\partial p} = \frac{1}{\theta p} \left(\bar{t} - t \right)$$

we see that the effect on savings slope is positive for $t < \bar{t}$ and negative for $t > \bar{t}$, given a small increase in p. A person who has a higher probability to survive each period will save more while young to meet this future contingency, and consequently save less later in life.

2.2.2 Time preference

Consider next a cohort specific rate of time preference. It is widely held that older cohorts are more patient than younger cohorts. The very patient initially consume very little. Consumption then grows as they consume the proceeds of their extra savings. We would then expect the older cohorts to consume less when young and have a more rapid consumption growth over the life cycle than another cohort with a higher time preference rate, all other things equal. We can derive the effect of δ on saving as

$$\frac{\partial S_t}{\partial \delta} = -\frac{1}{\theta \left(1 + \delta \right)} \left(\bar{t} - t \right)$$

An increase in the time preference rate (more impatience) reduces saving when $t < \bar{t}$ and increases savings when $t > \bar{t}$. In the opposite case, a patient consumer will save more while young and less before retirement, and because of the special feature of a drop in savings at retirement, he will also save more in the beginning of the retirement period than an impatient consumer.

2.2.3 Income uncertainty

We would expect that a household that faces increased income uncertainty also would initially consume less, save more and have a more rapid consumption growth over the life cycle, all other things equal. Consider first the case of an increase in expected variation of earned income:

$$\frac{\partial S_t}{\partial \sigma_1} = \theta\sigma_1 [T - \Phi] - \theta\sigma_1 t, \quad t \leq T$$

$$\frac{\partial S_t}{\partial \sigma_1} = -\theta\sigma_1 \Phi, \qquad T < t \leq T + N$$

where

$$\Phi = \frac{1}{(1 - R^{T+N})} \left(T - \frac{1 - R^T}{1 - R} \right)$$

and where Φ is positive if $T > \left(1 - R^T\right) / (1 - R)$ which can be shown will hold for $T > 0$, and for all reasonable values of R, T and N, Φ is also less than T. Given the values assumed earlier, Φ will be 23.43, which is numerically close to $\bar{t}$. Thus, an increase in expected variation of earned income has an ambiguous effect on saving during the working years, positive as long as $t < [T - \Phi]$, and negative from then until retirement. The increase in savings early in life leaves more for consumption in retirement, and reduces savings in old age.

Turning then to an increase in expected variation of retirement income.

$$\frac{\partial S_t}{\partial \sigma_2} = \theta\sigma_2 [\Phi + \bar{t} - T], \qquad t \leq T$$

$$\frac{\partial S_t}{\partial \sigma_2} = \theta\sigma_2 [\Phi + \bar{t}] - \theta\sigma_2 t, \qquad T < t \leq T + N$$

More uncertainty about income in retirement should induce the household to save more for retirement. The effect on savings for $t \leq T$ is positive when $\Phi > (T - \bar{t})$. It can be shown that this holds for all $N \geq 1$ (and $R \neq 1$). The effects on savings in retirement is ambiguous, since the precautionary motive still works for more saving while higher proceeds on previous savings should yield less saving. From the expression above we see that the effect on saving is positive as long as $[\Phi + \bar{t}] > t$, and negative thereafter. However, in my numerical example $[\Phi + \bar{t}] \approx 46.5 > T = 45$, and the effect of higher proceeds on previous savings would dominate.

2.2.4 Risk aversion

Turning now to the idea that older cohorts are more prudent. Consider a small increase in the coefficient of risk aversion (= intertemporal elasticity of substitution)

$$\frac{\partial S_t}{\partial \theta} = \frac{\partial \gamma_1}{\partial \theta} (\bar{t} - t) - \tfrac{1}{2} [\Phi + \bar{t} - T] \left(\sigma_1^2 - \sigma_2^2\right), \quad t \leq T$$

$$\frac{\partial S_t}{\partial \theta} = \frac{\partial \gamma_2}{\partial \theta} (\bar{t} - t) - \tfrac{1}{2} \Phi \left(\sigma_1^2 - \sigma_2^2\right), \qquad T < t \leq T + N$$

An increase in the coefficient of risk aversion has two effects on saving. First, it changes the savings slope. Since $\partial \gamma_i / \partial \theta = \frac{1}{2}\sigma_i^2 - \frac{1}{\theta^2} \ln\left(\frac{p(1+r)}{1+\delta}\right) > 0$, saving increases for ages $t < \bar{t}$, and decreases for ages $t > \bar{t}$. More risk averse consumers will save more while young, and consequently will save less when approaching retirement. Second, it has a negative effect on the level because of the difference in income variance. Higher degree of risk aversion reduces the value of uncertain income, and the value of labor income reduces more than retirement income when $\left(\sigma_1^2 - \sigma_2^2\right) > 0$. A person with higher risk aversion will thus transfer less through savings from the working period to the retirement period.

2.2.5 Summary

As a general result, any potential generational difference in mortality, preferences, or expectations, will have an impact both on the slope and on the level of the age-profile of saving. In the following sections I use Norwegian data to test whether we can find such differences in the slope and level of estimated age-profiles that can be attributable to birth cohort.

3 Data description

The main data source is the Norwegian Survey of Consumer Expenditures (SCE), which is an annual survey based on two weeks of expenditure accounting, with additional interviews. The interviews collect information on household characteristics, such as age and employment status of all members of the household, and expenditures that may not be properly covered by a two week accounting like durables and annual expenses. Thus total consumption expenditure consists of payments of the household during the accounting period, converted to figures for a whole year through multiplying with 26, together with the housing expenses and consumer durable purchases recorded in the interview. Income is added from tax records. The SCE is available for the period 1975-94. A more detailed description and an evaluation of the quality of the SCE-data is reported in Halvorsen (2002).

The unit of observation is a household, defined as persons having a common dwelling and sharing at least one meal per day. It is assumed that the household acts as a single decision maker so that we can apply the implications from the model above, and in the following most household characteristics are taken to be those of the household's main income earner, sometimes called the household head. Institutions are not included in the survey. The number of responding households is on the average 1170 each year, ranging from a minimum of 928 to a maximum of 1311. This is rather small, considering the large heterogeneity in variables like consumption and income. The non-response rate is approximately 0.4, where non-response is mainly due to refusal. The SCE contain non-response weights by household type, and all descriptive statistics below are computed using these weights.

The definition of household saving in this analysis is after-tax labor income including pensions and pure transfers, minus expenditures including consumer durables. Since the tax records have no information about transfers that are not subject to taxes, such transfers are imputed from household characteristics. The particular choice of savings definition employed above excludes capital income. In a recent seven country study of household saving (Börsch-Supan, 2001), a distinction is made between active and passive saving, passive saving being capital gains that are automatically reinvested. If all capital income is automatically reinvested, then the definition employed here is equal to active saving. Another reason for excluding capital income is one of measurement. While negative capital income is measured almost entirely, consisting principally of interest paid on mortgages, the corresponding positive receipts of capital income, i.e. imputed income from owner occupied housing, is inadequately registered. Also, saving in the theoretical model in section 2 is defined as non-consumed labor income.

There are several difficulties with using these data, mainly due to the manner in which consumption is measured and aggregated. For example, it seems likely that there are measurement errors both in the registration of expenditures on durables based on recall, and in the registration of expenditures on non-durables through scaling up two weeks of purchases. Another source of measurement error is the lack of exact correspondence between income and consumption. While income refers to the year of observation, consumer expenditures depends on when the household has been interviewed. In the interview, questions about expenditures on durables are phrased "purchased in the past 12 months". An interview done in January will record expenditures on durables in the current year that were actually made in the year before. There is also a correspondence problem with the procedure of scaling up two weeks of expenditures to one year. Households interviewed in December will in most cases yield an observation of a much higher yearly expenditure (when the two weeks are multiplied by 26) than other households with the same yearly income interviewed at an earlier date. In the empirical part of the paper, dummies for month of interview is included as an attempt to correct for these errors.

In general, the measure of saving will be disturbed by measurement errors in both expenditures and income, although apparently in no systematic manner. Furthermore, the SCE saving rates by year seems to fit the National Accounts' saving rate after some corrections for diverging definitions in the two measures, even if the micro series exhibit more fluctuation over time (more on this in Halvorsen, 2002).

Table 1: Saving rates by age and year

	All	25-34	35-44	45-54	55-64	65-74
1975	.11 (.71)	.06 (.60)	.04 (.68)	.11 (.68)	.15 (.81)	.20 (.74)
1976	.14 (.61)	.06 (.57)	.05 (.62)	.18 (.49)	.19 (.64)	.28 (.78)
1978	.15 (.66)	.07 (.55)	.09 (.65)	.17 (.62)	.21 (.73)	.20 (.66)
1979	.16 (.63)	.05 (.58)	.05 (.57)	.18 (.61)	.33 (.51)	.26 (.79)
1980	.14 (.57)	.12 (.52)	.09 (.47)	.10 (.63)	.23 (.67)	.27 (.64)
1981	.18 (.61)	.12 (.54)	.11 (.57)	.16 (.62)	.32 (.61)	.29 (.71)
1982	.19 (.56)	.11 (.52)	.11 (.51)	.22 (.48)	.28 (.55)	.30 (.74)
1983	.13 (.67)	.04 (.57)	.06 (.61)	.13 (.57)	.18 (.69)	.31 (.91)
1984	.11 (.68)	.06 (.63)	.03 (.59)	.08 (.79)	.20 (.56)	.16 (.70)
1985	.11 (.65)	.03 (.69)	.04 (.55)	.13 (.65)	.18 (.69)	.30 (.77)
1986	.07 (.60)	.01 (.72)	.00 (.55)	.07 (.60)	.17 (.52)	.17 (.66)
1987	.08 (.63)	-.01 (.66)	-.02 (.59)	.14 (.63)	.17 (.56)	.23 (.50)
1988	.18 (.55)	.08 (.61)	.18 (.49)	.23 (.42)	.21 (.52)	.25 (.59)
1989	.12 (.51)	.03 (.56)	.04 (.48)	.10 (.45)	.18 (.55)	.23 (.43)
1990	.14 (.49)	.05 (.54)	.14 (.46)	.15 (.47)	.24 (.52)	.21 (.56)
1991	.11 (.56)	-.00 (.60)	.04 (.48)	.16 (.54)	.26 (.48)	.18 (.54)
1992	.16 (.53)	.16 (.54)	.11 (.50)	.15 (.57)	.21 (.59)	.24 (.42)
1993	.18 (.48)	.07 (.63)	.13 (.42)	.23 (.47)	.21 (.47)	.24 (.48)
1994	.22 (.49)	.08 (.55)	.22 (.43)	.21 (.51)	.32 (.47)	.27 (.53)
Average no of obs	1171	275	284	224	217	171

Note: Median of all households in each age group, by age of main income earner. Interquartile range in parenthesis.
Source: Author's calculations using the SCE and tax records, Statistics Norway

3.1 Descriptive statistics

According to the life-cycle or permanent income hypothesis, consumption is proportional to the expected present value of lifetime resources, and savings will be positive when current income is above permanent income level and negative when current income is below. As such, the simple life-cycle hypothesis implies that households will accumulate wealth by saving during most of their working years and then dissave in retirement. In the particular version of the life-cycle model introduced in the previous section, with uncertainty and impatience, saving increases with age until the drop at retirement.

Table 1 presents the median saving rates of different age groups for all years in the sample. Age refers here to the age of the main income earner in a household. The medians fluctuate substantially between years, reflecting the overall problem of large variation in the distribution of saving rates. The distribution is also very much skewed to the right with large negative outliers. The data show that saving rates seem to increase steadily with age, showing no decline for the retired. Actually, the saving rate are remarkable high after the age of 54, where we normally expect saving to peak, and the saving rates of the 65-75 year old are extraordinarily high.

There is a great deal of evidence that old people save, or at least do not dissave as implied by the simple life-cycle model without bequests. Such evidence goes back at least as far as Mirer (1979) and is continuously updated as new data sets become available. According to many household surveys from around the world, rates of saving among elderly households are as high or higher than among younger households, who are supposed to be saving for retirement. Despite institutional differences, such saving patterns have been observed among the elderly in the United States, the United Kingdom, Germany, and Italy (see Poterba, 1994, Attanasio, 1998, Börsch-Supan, 2001). These results can be made consistent with uncertainty about the date of one's death, the risk of high unplanned expenditures due to illness or the need of care, the desire for social status, or the intention to leave an estate to one's heirs. In a recent Norwegian survey by NOVA on attitudes toward saving and bequests (Gulbrandsen and Langsether, 2001), the majority of the households stated to save as a precaution against unforeseen contingencies, while saving in order to leave an estate was the second most important motive. The relative weight placed on the different motives did not seem to change with age.

3.2 Synthetic panels method

It is not easy to identify difference by birth cohort in table 1. The generation that was 25-34 years old in 1975, would be 35-44 years old in 1984, and so on. We can compare this generation with the one that is 25-34 years old in 1985 and 35-44 years old in 1995, but table 1 does not give enough information to draw any conclusion about cohort differences in this manner. Since no panel data on Norwegian household consumption and saving are available, one must rely on repeated cross-sectional data by using the variation in the behavior of each

Table 2: Cohort statistics

Cohort	Year of birth	Age in 1975	Age in 1994	Av cell size
1	1905-14	61-70	80-89	84*
2	1915-24	51-60	70-79	206
3	1925-34	41-50	60-69	197
4	1935-44	31-40	50-59	216
5	1945-54	21-30	40-49	295
6	1955-64	11-20	30-39	167*

* based on 10 to 15 years of observation

Source: Author's calculations from the SCE, Statistics Norway

cohort over time to estimate cohort-specific profiles from several waves of cross-sectional data. If each year's cross-section is a random sample, then following Deaton (1985), it is possible to construct "synthetic cohort profiles" by linking together saving rates of i.e. 45-year-olds in year t and 46-year-olds in year $t+1$.

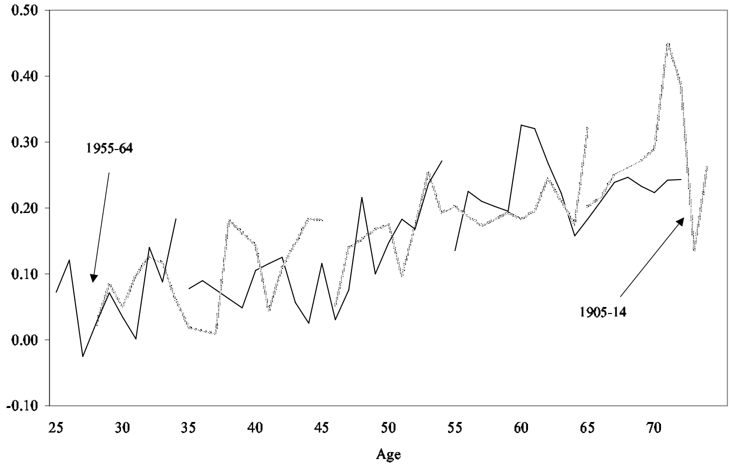
A cohort is defined as all households whose head is born in a certain period. In this study, birth cohorts are defined by ten-year bands. Cohort 1 is the eldest with household heads born between 1905 and 1914 and cohort 6 the youngest with household heads born between 1955 and 1964. Thus, cohort 5 would be the "baby-boom" generation. The cohort definition, the age intervals in 1975 and 1994, and the average cell size is reported in table 2. In the subsequent analysis I have excluded observations of ages below 25 and above 74, since at these ages the combination of age, period and cohort yields too small cells. This is because the eldest and the youngest cohorts are not observed over the whole sample period. With this exception, each cohort is observed in every cross-section, but consists of a different set of households each time. Consider a variable of interest, x_p^{ch}, observed for household h, belonging to cohort c in period p, It is always possible to define ε_p^{ch} by the following equation

$$x_p^{ch} = \delta_p^c + \varepsilon_p^{ch}$$

where δ_p^c is a measure of location (means, median etc.) for the cell defined as households belonging to cohort c in period p, and ε_p^{ch} is the deviation from the measure of location. The age corresponding to cell (c, p) is given as long as cohorts are identified by year of birth.

The estimated median saving rates for such year-cohort cells against age is plotted in figure 1. Each connected segment represents the behavior of a cohort over the sample period. Since a cohort is defined as a ten-year interval and I have 20 years of data, each cohort overlaps for 10 ages. It is the vertical difference between these overlapping segments that may be interpreted as "cohort-effects". Based on the figure it is almost impossible to draw any conclusions because of the fluctuation of each segment over time. The volatility in the time-series are principally due to the consumption boom in the mid-1980, but also the large variation in the micro series in general.

Figure 1: Median saving rates by age and cohort



There are essentially two ways of exploring cohort effects empirically. One is the method of using synthetic panels for graphical illustrations, as in figure 1. This is the principal presentation form used in the International Savings Comparison Project (Börsch-Supan, 2001), and the basis for Attanasio's (1998) conclusions about cohort effects as one of the factors explaining the decline in the U.S. saving rate. The other way of evaluating the effect of cohorts is through regression where the aim is to separate the three effects age, period and cohort.

4 Empirical characterization of saving rate profiles

Let a denote the age of a household (head) and p the period of observation, in this case a calender year. A cohort c is defined by the year of birth of the household head. The following trivial identity links the three quantities age, cohort and calender year:

$$p = c + a \tag{6}$$

Studies of consumption and savings often investigate movements in age-profiles. Consider an age-profile in saving rates (sr)

$$sr\,(a,p) = f\,(a,p) + u \tag{7}$$

The deterministic function f measures the systematic variation in saving rates and the error u reflects cyclical or transitory phenomena. For a fixed year p, the function $f\,(a,p)$ yields the conventional cross-section. Movements of f

as a function of p describe how cross-sectional saving profiles shift over time. Recognizing relation (6), the cross-section as a function of age does not describe life-cycle saving rates for any cohort, or put differently, the cross-section relation may very well be the result of cohort effects. In fact, cohort-savings-profiles are statistically indistinguishable from age-savings-profiles. Saving rates can also be expressed as a function of cohort and age

$$g(c,a) \equiv g(p-a,a) \equiv f(a,p) \tag{8}$$

where the deterministic function g describe how age-savings-profiles differ across cohorts. Holding age constant $g(p-a,a)$ describes the profile of saving for a cohort over time. Holding the cohort constant yields the profile experienced by a specific cohort over time and age, this being the life-cycle profile.

The identification problem arises because there is no independent variation in the three variables age, period and cohort. All age effects can be perceived as a combination of period and cohort effects, all period effects as a combination of age and cohort etc. In particular, all cohort effects can be seen as a result of having a certain age in a certain period.

While the problem of identifying effects in age, period and cohort-models is a general one, it yields multicollinearity in the special case of a linear additive model. Consider a linear additive version of (7)

$$sr(a,p) = k_0 + \zeta a + \phi p + u \tag{9}$$

where k_0 is a constant and ζ and ϕ are parameters. If the parameters are composite effects $\zeta \equiv (\gamma - \rho)$ and $\phi \equiv (\eta + \rho)$, then we can by (6) rewrite (9) as

$$sr(a,p,c) = k_0 + \gamma a + \eta p + \rho c + u \tag{10}$$

where γ, η and ρ are parameters, the latter corresponding to what we would call a cohort effect. We have an identification problem if γ, η and ρ are free. This is solved if one of the three is known, e.g. set to zero.

Despite its restrictive form, the linear additive model is a widely used empirical specification in studies of age, period and cohort effects in household variables. Because of the multicollinearity problem it is a specification that requires additional restrictions on the parameters, or other ways of solving the identification problem. Some sort of out-sample-information as a proxy for the cohort effect was suggested by King and Dicks-Mireaux (1982) for wealth equations and by Heckman and Robb (1985) for earnings equations. Productivity growth is one such proxy. However, this is also a restrictive approach as it presupposes, not only that there are in fact cohort effects, but also the specific source of these effects.

The other approach is to impose additional restrictions on the parameters in the model. Deaton and Paxon (1994) propose a method that decomposes all three effects, using an additive model with dummies for each age, period and cohort, controlling for household characteristics. The multicollinearity problem is solved by assuming that the period effects sum to zero and by omitting the first two period dummies[1]. Plotting the dummy-parameters for each variable then gives a graphical impression of the decomposition of effects. It can be shown that applying this method on the saving rates from the Norwegian SCE data, the estimated parameters for the age dummies (one for each year of age) suggest that saving rates as a function of age is best represented by a 5th degree polynomial in age. A 5th degree polynomial takes care of the special features that saving increase by age for the young, then stays approximately constant for households in their thirties and early forties, after which saving grows again, the slope increasing with age.

Thus a general regression equation for the saving rate of household i in the sample year p, can be written

$$sr_p^i = k_0 + \sum_{j=1}^{5} \gamma_j (a)^j + \eta' D_p + \rho_c' D_c + X^i \boldsymbol{\beta} + \kappa \frac{1}{y_p^i} + u_p^i \tag{11}$$

where D_p and D_c are sets of cohort and year dummies, and X are household specific variables we want to control for (employment status, area of residence, female head, number of adults, number of children, homeownership, month of interview). The η's are constrained to have zero mean. The dummies for cohort are normalized on the youngest cohort, while the dummies for period are a set of $T-2$ dummies where, as in Deaton and Paxon, the first two periods are excluded in the regression. The inverse of household labor income after tax $\left(y_p^i\right)$ is included because by construction saving rates become increasingly negative as income diminishes, yielding extreme negative saving rates for households with incomes close to zero. Equation (11) is an approximation of a relation where saving is assumed to be a linear in the age-polynomial, period specific shocks, cohort and household characteristics, and where it has been transformed to a saving rate relation by dividing with income. As such we expect the error term to be proportional with the inverse of income.

It has been argued that age, period and cohort specifications are doomed to fail with the introduction of constraints because this would necessarily result in biased estimates, or that even if constraints are technically feasible, they are practically inadmissible because the chances of making a theoretically correct restriction–and knowing that you have done so–is negligible (Glenn, 1976). The Deaton approach relies heavily on the treatment of period effects. The assumption that the period effects sum to zero in the long run, implying that the variable period is a proxy for macroeconomic shocks, may not be unreasonable in this case. However, solving the multicollinearity problem by omitting two period dummies seem more randomly chosen. On the other hand, I have attempted to omit other pairs of period dummies and this did not change any of the main results.

[1] This method for solving the multicollinearity problem could be applied to any of the dummy matrices. Since consumption was the dependent variable in Deaton and Paxon (1994), it was also assumed that the time effects were orthogonal to a linear trend. According to the macro series, or the time series of the median, the assumption of a trend is not evident when studying saving rates.

4.1 Problems with measurement errors, heteroskedasticity and outliers

In ordinary least squares (LS) it is assumed that the errors u satisfy, or at least approximately satisfy, the classical assumptions of constant variance and normal distribution. In a LS regression on equation (11), all normality tests show rejection of the normality hypothesis, as do tests of the assumption of constant variance of u. This implies that the standard errors of the estimates in are incorrect and any inferences derived from them may thus be misleading. I suspect that a cause of heteroskedasticity in the saving rate is low income level. This is confirmed by a plot of residuals by income, see appendix C. Low registered labor incomes may partly be attributed to households that have positive capital incomes, which is omitted from the income measure, or to households who have transitory low incomes, in particular some younger households. A closer inspection of saving rate outliers reveals that some are due to young households, but the majority of the outliers are households with heads aged 60 or more and that a majority of the extreme values in this age group can be accounted for by positive capital income.

Thus both classical assumptions are violated in the LS regression, the distribution is left skewed and the errors are larger the lower the income level. The most common way of dealing with heteroskedasticity is to give observations with large variance less weight in the regression. In the next sections I provide regression results for equation (11) using different methods of weighting, trimming and robust regression. I show that even if we may, to a certain extent, meet the data problems through weighting, it is still difficult to find any significant effect of including dummy-variables for cohort in the saving rate regressions. In section 5 I turn to other settings such as data transformation and choosing saving levels instead of saving rates as the dependent variable. As we shall see, this does not change the basic insight that cohort effects are weak in the data.

4.2 Regression results

Weighting involves decisions about which outliers should have less weight in the regression than others. In this case we know that a majority of the outliers are caused by the construction of the dependent variable, and as the plot of the LS residuals in appendix C suggests, the variance is proportional to income at least for incomes less than 350000 kroner. This suggests that an appropriate weight (w) could be

$$w = \begin{cases} y^2 & \text{if } y < \lambda \\ \lambda^2 & \text{if } y \geq \lambda \end{cases} \tag{12}$$

with $\lambda = 350000$.

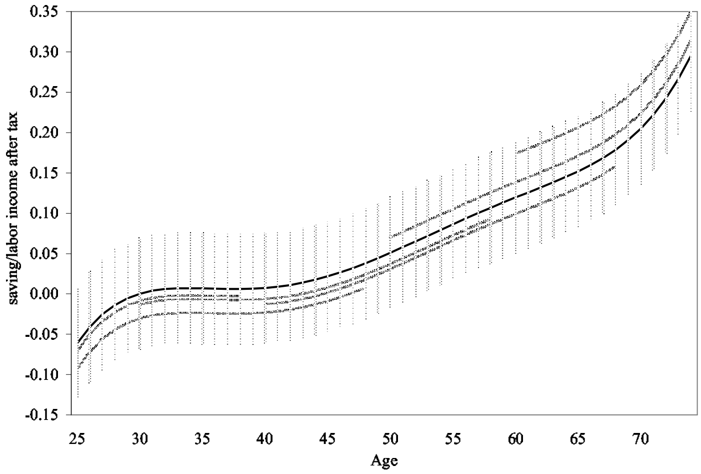
The result from using this weight when estimating (11) is presented as model (2) in table 3. In the first column I report the parameter estimates from the ordinary least squares regression for comparison. All regressions include a fifth degree polynomial in age of the household head, household characteristics such as number of children (and number of children squared) and number of adults,

Table 3: Saving rates regression, Eq. (11)

	LS	WLS	Reweighted LS	
	Model (1)	Model (2)	Model (3)	Model (4)
		$w = y^2$	metric trim	LTS
Intercept	1.07 (.20)	0.60 (.03)	0.81 (.05)	0.41 (.02)
Sel. dummies:				
Birth cohort 1905-14	-0.39 (.31)	0.08 (.04)	-0.01 (.07)	0.05 (.03)
Birth cohort 1915-24	-0.21 (.25)	0.04 (.03)	-0.01 (.06)	0.02 (.03)
Birth cohort 1925-34	-0.26 (.20)	0.02 (.02)	-0.06 (.05)	-0.00 (.02)
Birth cohort 1935-44	-0.16 (.14)	-0.01 (.01)	-0.07 (.03)	-0.01 (.02)
Birth cohort 1945-54	-0.07 (.09)	-0.01 (.01)	-0.00 (.02)	-0.01 (.01)
Birth cohort 1955-64	0	0	0	0
Self-employed head	-0.13 (.06)	-0.00 (.01)	-0.05 (.01)	0.02 (.01)
Rural area (spars. pop)	0.39 (.06)	0.16 (.01)	0.25 (.01)	0.15 (.01)
Rural area (dens. pop)	0.20 (.05)	0.06 (.01)	0.10 (.01)	0.06 (.01)
Homeowner	-0.02 (.05)	-0.05 (.01)	-0.07 (.01)	-0.03 (.01)
No of children	-0.22 (.05)	-0.09 (.01)	-0.14 (.01)	-0.10 (.01)
No of children^2	0.03 (.01)	0.01 (.00)	0.02 (.00)	0.01 (.00)
No of adults	-0.15 (.03)	-0.05 (.00)	-0.14 (.01)	-0.04 (.01)
adjR^2	0.87	0.23	0.71	0.38
Breusch-Pagan	8219	273.5	4101	n.a.
$\chi^2\,(2)$	($<.0001$)	($<.0001$)	($<.0001$)	
Kolmogorov-S	0.342	0.065	0.125	n.a.
(p-value)	($<.0100$)	($<.0100$)	($<.0100$)	

Standard errors in parenthesis. The Breusch-Pagan tests the null hypothesis of homoskedasticity in the variables $1/y_i$ and $1/y_i^2$. The Kolmogorov-Smirnov tests the null hypothesis of normality of the standarized residuals. A full set of regressors for model (2) and (4) is given in appendix E.

Figure 2: Fitted age-polynomials, saving rates



dummies for self employed head and self-employed spouse, female head, homeownership, and two categories of rural area, sparsely populated and densely populated. A selection of these dummies are presented in table 4. The reference group is households headed by a male wage-earner, residing in a major city, and belonging to the youngest birth cohort. Included is also a set of dummies for the month the interview took place, normalized on August. Finally, there is a set of restricted time dummies as described in the previous section. The full set of estimates can be found in appendix E. In the lower part of the table, I have presented some goodness-of-fit and tests statistics. Since the problems of the error term concerned non-normality and heteroskedasticity, I have chosen a test statistic for each. The Kolmogoro-Smirnov-statistic assess the discrepancy between the empirical distribution and the estimated hypothesized normal distribution of the standardized residuals. The Breusch-Pagan tests the null hypothesis of homoskedasticity on the variables $1/y_i$ and $1/y_i^2$.

The estimated age-polynomial show that age effects in saving rates are powerful. Saving rates increase steadily over the life-cycle. The main features of the fitted age-polynomial of model (2) is summarized in Figure 2. The solid line represents the estimated age-polynomial in a regression similar to model (2), but without dummies for birth cohort. Two features are worth noticing in this chart. First, the profiles exhibit a remarkable increase after the age of 50, where we normally would expect saving to peak. Second, the cohort effects are modest, and even though there is a tendency for the two oldest cohorts to exhibit higher saving rates at all ages, their cohort segments lie within the 95%-confidence interval (the vertical lines in the figure) of the level of estimated age-polynomial from a regression without the inclusion of dummies for cohort.

So, the basic insight is that after weighting by income the estimates for cohort indicate that there is a tendency for the two eldest birth cohorts to save more than later cohorts. Households with heads born in 1905-14 are estimated to have saving rates at 8 percentage points higher at all ages than households with heads born in 1955-64. Put differently, the results suggest that the baby-boom generation has saving rates on the average 3-5 percentage points lower than generations born before the II World War. Compared to the magnitudes of the age effect, this does not amount to very much. Leaving out capital income in the definition of income skews the estimated age profile, underestimating saving rates for old ages and overestimating saving rates for young ages, but does not change the conclusion about the cohort-effects. We observe also that the standard errors increase for the eldest generations, making the estimates insignificantly different from each other at conventional statistical levels. The errors probably increase for several reasons. First, we have fewer observations of the oldest cohorts. Second, to the extent that we have been able to separate age effects and birth cohort effect, the period of observation is not long enough to escape the fact that observations of early generations are still observations of old households. Finally, we must remember that in Western Europe, the cohort born in the mid-1920s is the first to have an uninterrupted 40-year work history, not punctuated by wars, inflations and political turmoil. As such, the estimates for cohort effects do not provide reason to explain the cross-sectional observation of very high saving among the elderly primarily as generational, but that the high saving must be due to other reasons such as precautionary saving or a bequest motive.

The results in table 3 also reveal a powerful impact of region and the demographic composition of the household upon the saving rate. Region has a strong and consistent pattern of influence upon household saving in all years. Relative to a household in one of the major cities (Oslo, Bergen or Trondheim), a household with similar characteristics in sparsely populated areas have significantly higher saving rates, on the average about 16 percentage points higher. Reasons for this may be a combination of attitudes and availability of consumer goods and services. In more densely populated areas the saving rates are around 6 percentage points higher than in the major cities. The number of children aged 19 or younger has a large and significantly negative impact on household saving, an additional child lowers household saving by 9 percentage points. Despite the increase in income through child benefits and tax deductions, these transfers are seldom enough to meet the costs of having children, considering that families with dependent children tend to be more established and established in larger dwellings than households of the same age and characteristics but without children. It is usual to assume some advantages of scale in the household since some goods consumed may be considered as collective goods. However, we observe that the number of adults affects the saving rate negatively. The same result appears when the variable 'number of adults' is replaced with the variable 'number of heads'. While the negative effect of having more than two adults in the household is intuitive when the additional adult is a child 20 years or older (as in most cases in the sample), or an elderly dependent parent, it is not so clear in the case of going from one to two adults. It is possible that couples are more likely than singles to be established, have mortgages and invest in durables, but this is just a presumption.

The dummy for self-employed head seems important in the least squares fit, but is rendered insignificant after weighting by income. This suggests that the measurement errors in income is greater for this group than for wage-earners. The distinction between renters and homeowners is made for two reasons. In the first place, the initial conditions for the two groups are different, one has housing wealth and the other has not. As income from housing is not included in the income concept, but rental payments on mortgage loans are entirely included in housing consumption, we would expect the saving concept employed to give lower saving for homeowners than for renters. Lower saving for homeowner may also be the result of wealth effects in consumption, although such effects are still discussed in the empirical literature. The coefficient in table 3 is in fact significantly negative, confirming the assumptions above.

Next, I consider the goodness-of-fit and the test statistics. The Kolmogorov-Smirnov statistic is less than .01, thus outside the range of critical values given by Stephens (1974) and rejecting the normality hypothesis. However, the statistic in the weighed least squares is half the size of the statistic in the ordinary least squares regression. The Breusch-Pagan test still rejects homoskedasticity in income after weighting by income, and in this respect one might find the statistic too large. Nevertheless, compared to the least squares statistic it shows a large improvement. Obviously, when outliers have less weight in the regression, the estimated model will also explain less of the overall variance. This is why the R-squared is considerably smaller in the weighted least squares regression than in the least squares regression.

In appendix E the full set of regressors are presented, among these are the dummies for month of interview and the restricted years dummies. Note that Christmas shopping influences strongly expenditures recorded in December, and subsequently expenditures recorded in January are overall lower than in other months. The estimates from the restricted year dummies are close to the sample median saving rate by year, confirming the impression that this restriction does not disturb the other estimates in any significant manner. However, this must be considered along with the initial restriction of assuming linear separability in age, period, and cohort effects. The decomposing of effects based on simple additive models implicitly assume that age effects are the same for each cohort and period, period effects are the same for each age level and cohort, and cohort effects are the same for each age level and period. For example, macroeconomic fluctuations are taken to influence all ages or all birth cohorts in the same way. In view of the fact that during the time period observed, Norwegian households experienced liberalization in both the credit market and the housing market, periods of high unemployment and large changes in the real interest rate, it would seem like a crude approximation to assume that all households were affected in the same way by these factors.

4.2.1 Does the age-slope vary with cohort?

Another specification is one where some kind of interaction between age and cohort is assumed. As pointed out by Heckman and Robb (1985), the introduction of higher-order interaction does not solve the identification problem (or the multicollinearity problem). Still, one may argue that additive models such as the ones presented above are too simple and that there may be potentially meaningful interactions between the variables. In section 2 it was shown that conceivable cohort specific parameters in a life-cycle model could change both the intercept and the slope of the age-savings profile. This would indicate that an econometric specification including an age-cohort interaction would be more appropriate. I still assume that period effects are the same for each age level and each cohort, and apply the same restrictions on the period dummies as in the previous section. However, a pure age-cohort interaction with age represented as a fifth degree polynomial will inevitably lead to an unwieldy amount of parameters. The following approach is an alternative.

Denote the estimated age-polynomial from equation (11) as

$$\hat{p}(a) = \sum_{j=1}^{5} \hat{\gamma}_j (a)^j \tag{13}$$

where a is actual age. Rescaling the age variable as deviation from the tilt-point ($\bar{t}_R$) in the theoretical section, we can also rescale the estimated polynomial as a function of the deviation from the tilt-point, $\hat{p}(\tilde{a})$, where $\tilde{a} = a - \bar{t}_R = a - 43$. The variable $\hat{p}(\tilde{a})$ is then used in a new regression model with specified interaction between the polynomial, age and dummies for each cohort in the following manner

$$sr_p^i = k_0 + b_0 \hat{p}(\tilde{a}) + b_c' \hat{p}(\tilde{a}) \frac{\tilde{a}}{50} D_c + \eta_p' D_p + \rho_c' D_c + X^i \boldsymbol{\beta} + u_p^i \tag{14}$$

Here I allow for the polynomial to tilt around $\bar{t}_R$, with the parameters b_c reflecting that different cohorts may have different age-slopes, in addition to the ρ_c's that account for cohort-specific levels. It is thus assumed that the shape of the age-profile is common for all cohorts.

The results of the estimation is presented in table 4, showing only the estimated $\hat{b}_c$'s and $\hat{\rho}_c$'s. Adding a cohort specific slope coefficient to the age polynomial changes somewhat the estimated level coefficients. In this case, we get a significant drop in the saving rates level for the 1935-54 cohorts. However, in view of the fact that the slope coefficients are insignificantly different from zero, and the goodness-of-fit and test statistics remain unchanged, the alternative specification in (14) does not seem more suitable than the simple additive model to analyze cohort-effects. In this respect, it is not obvious that the dummy coefficients for the 1935-44 and 1945-54 generations provide any new and altering evidence on the cohort effects.

Table 4: Saving rate regression, eq. (14)

	Model (5) WLS	
	Level (ρ_c)	Slope (b_c)
Birth cohort 1905-14	0.02 (0.05)	0.39 (0.57)
Birth cohort 1915-24	0.03 (0.03)	-0.13 (0.51)
Birth cohort 1925-34	0.02 (0.02)	-0.39 (0.71)
Birth cohort 1935-44	-0.14 (0.01)	-0.09 (1.33)
Birth cohort 1945-54	-0.17 (0.01)	1.31 (2.53)
Birth cohort 1955-64	0	-1.57 (1.99)
adjR^2	0.23	

Standard errors in parenthesis.

4.3 Robustness of the results

An alternative to assuming a specific functional form of the variance, is trimming of means and robust regression that treat outliers as gross errors or corruption in the data. The easiest way is to apply a re-weighting procedure with so called metric trimming, which gives large outliers in the LS regression no influence at all. In this case the weights (w) are constructed as

$$w = \begin{cases} 1 & \text{if } \left|\frac{r_i}{\sigma}\right| \leq \lambda \\ 0 & \text{if } \left|\frac{r_i}{\sigma}\right| > \lambda \end{cases} \tag{15}$$

for some level of the constant λ, where r_i is the residual. The result of this procedure when $\lambda = 2$ is presented in the third column of table 3 as model (3)[2].

However, re-weighting on the basis of ordinary least squares residuals may be misleading since the LS fit has already been pulled in the direction of deviating observations. Thus an outlier might a have much smaller LS residual than the resulting residual from a more robust regression. Robust regression is used as a term that covers many methods which try to design estimators that are not too strongly influenced by outliers. The sample mean of a dependent variable can be upset completely by a single outlier. This contrasts with the sample median which is little affected. We say that the median is resistant to gross errors while the mean is not. Many robust methods are therefore aimed at using the median as the estimator of location in the regression model.

Among these methods the least median of squares (LMS) minimizes the median of the squared residuals.

[2] I find that more sophisticated re-weighting based on M-estimators like the Huber-estimator or the Hampel-estimator do not yield results that differ much from the simple procedure in (15).

$$\min \left\{ \underset{i}{\text{med}} r_i^2 \right\}$$

and the least trimmed squares method (LTS) minimizes the sum of the h smallest squared residuals:

$$\min \sum_{i=1}^{h} \left(r^2\right)_{i:n}$$

where $(i:n)$ represents an ascending ordering of the squared residuals (r), and

$$h = \frac{n+p+1}{2}$$

where n is the number of observations and p is the number of estimated parameters (Rousseeuw, 1984). If $h = n$ then the LTS fit equals the least squares fit. Applied on small data sets the two methods give the same result, but Rousseeuw and Leroy (1987) has shown that the least trimmed squares method is statistically more efficient than the least median of squares method for large data sets. However, the LTS estimator is still computational intense, in particular when the number of right hand side variables is large. In table 4 the LTS is based on a new and improved algorithm (Rousseeuw and Van Driessen, 1998) and the results presented in the fourth column as model (4) are from a re-weighted least squares regression using the weights returned from LTS.

Not surprisingly, the two re-weighting procedures described above reduce all standard errors. The dummy for self-employed has reduced influence after trimming, since this group represent sources for measurement errors, and is likely to be given zero weight in the re-weighting procedure. The variable number of children in the household and the dummy for residing in sparsely inhabited areas, both have coefficients that become somewhat smaller and more accurate after trimming, but remain important variables in determining the household saving rate.

The LTS re-weighting yields a further reduction in the standard errors compared to the metric trimming, but the cohort effects are still not significantly different from each other, although the pattern now indicates slightly higher saving rates for the two eldest birth cohorts. Yet, the errors are not reduced enough to render the cohort effects statistically significant for each other at any conventional level.

Judging from these results and the test-statistics, my preferred specification is model (2). The LTS-method is considered to be very robust and it is therefore interesting that models (2) and (4) yield such similar results. This indicates that the extreme value and variance problem is indeed determined by heteroskedasticity in income.

Alternatively, heteroskedasticity with respect to an economic magnitude is usually approximately removed if the regression equation is applied to its logarithm. This is why log-transformation of a variable is widely used on household variables like consumption and income. Log-transformation suppresses extreme values but require initially positive values and is therefore not feasible when

Table 5: Log consumption regression, Eq. (16)

	LS Model (6)	WLS $(w = y^2)$ Model (7)
$\ln y_i$	0.28 (.01)	0.54 (.01)
Selected dummies:		
Birth cohort 1905-14	-0.03 (.06)	-0.09 (.06)
Birth cohort 1915-24	-0.05 (.05)	-0.05 (.04)
Birth cohort 1925-34	-0.03 (.04)	-0.03 (.03)
Birth cohort 1935-44	-0.00 (.03)	-0.01 (.02)
Birth cohort 1945-54	-0.00 (.02)	0.00 (.01)
Birth cohort 1955-64	0	0
Self-employed head	-0.03 (.01)	-0.05 (.01)
Rural area (spars. pop.)	-0.33 (.01)	-0.24 (.01)
No of children	0.20 (.01)	0.12 (.01)
No of children^2	-0.03 (.00)	-0.02 (.00)
No of adults	0.20 (.01)	0.08 (.01)
adjR^2	0.48	0.40
Breusch-Pagan	2036	689.4
χ^2 (2)	$(< .0001)$	$(< .0001)$
Kolmogorov-S	0.031	0.057
(p-value)	$(< .0100)$	$(< .0100)$

Standard errors in parenthesis. Breusch-Pagan test of the null hypothesis of homoskedasticity in variables $1/y_i$ and $1/y_i^2$. The Kolmogorov-Smirnov tests the null hypothesis of normality of the standardized residuals.

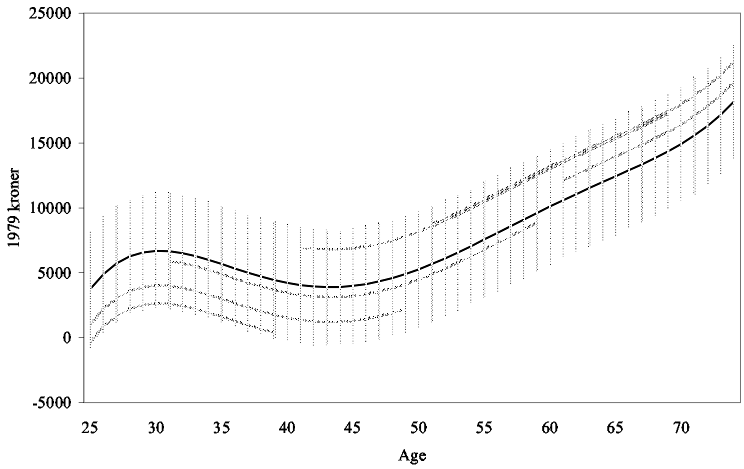
dealing with savings. An alternative is to use the average propensity to consume ($c/y = 1 - s/y$) and translate the results back to saving rates afterwards. Since the data used in the regression contains no negative or zero labor incomes it is possible to take logs of the average propensity to consume, and we get the following equation for estimation[3]

$$\ln c_p^i = \ln y_p^i + \tilde{k}_0 + \sum_{j=1}^{5} \tilde{\gamma}_j (a)^j + \tilde{\eta}' D_p + \tilde{\rho}_c' D_c + X^i \tilde{\beta} + \tilde{u}_p^i \tag{16}$$

Table 5 presents in the first column the LS fit of equation (16), labelled as model (6). As expected, income is a prime determinant of spending. The Breusch-Pagan test for model (6) and the plot of residuals against income in appendix D show that the LS residuals in model (6) are still highly heteroscedas-

[3] In most empirical consumption studies the polynomial in age is assumed to be of third degree, but for the purpose of translating back to saving rates I will keep the 5th degree polynomial.

Figure 3: Fitted age polynomials, saving level



tic, even after the transformation. On the other hand the plot in appendix D also suggests that the log-transformation has reduced somewhat the problem of large outliers and made the distribution by income considerably more symmetric. It seems like the variance function in (12) can be sensible also in a weighted least squares for log consumption. The result is presented as model (7) in table 5. The general effect of transformation is the same as for trimming and robust estimation, standard errors are reduced, but not enough to make the cohort effects significant. As is seen by the Kolmogorov-Smirnov statistic, the log-transformation does well in dealing with the skewness problem, but overall not much better than weighting by income in the previous section.

The life-cycle hypothesis have implications about consumption and saving, and not directly about saving rates. Add to this that saving rates are noisy by construction, and thus a problematic variable empirically, and it is perhaps not surprising that most studies of household saving describe saving levels instead of rates. In figure 3 I report the fitted age polynomial for saving levels with and without the estimated cohort specific levels in a figure similar to figure 2. The fit is based on a weighted least squares regression of saving levels against income, a fifth-degree polynomial in age, and the same controls as in the previous regression models. On the other hand, while the permanent income theory predicts that current consumption should be independent of current income, saving as the residual will be dependent of fluctuations in current income. Moreover, for the purpose of policy evaluations we are more interested in saving rates than saving levels.

5 Conclusion

It seems that as a matter of theory, generational differences in preferences and expectations should manifest itself in both the level and the slope of the age-savings rate profile. The empirical evidence provided in this paper show a tendency for the eldest cohorts to exhibit higher saving rates for all ages, but that these differences are small and insignificant. Extending the specification to allow for variable slopes as well as levels of the age-saving profile does not improve on this result. However, because of the short panel, the oldest cohorts are only observed at ages where the saving rates also exhibit large variation. There are other reasons why we would expect more noise around the estimates of retired households. There are fewer observations of the old birth cohorts because institutionalized elderly are omitted from the sample. Moreover, it is reasonable to assume that skewness of income within an age-group rise with age, which would have effect if saving rates depend on level of income.

The upshot is that based on consumption and income data for Norwegian households in the period 1975-94, there seems to be weak evidence for any cohort effects that might explain high saving in retired households, or the high and increasing aggregate saving rate. Nor is there any reason to believe that the aggregate saving rate will be affected by the "baby-boom"-generation, other than by its size. Generally, the lack of strong generational differences in saving suggest that one should put less emphasis on explaining cohort effects in consumption and wealth as due to, for instance, patience or prudence, and more emphasis on explaining cohort effects as differences in productivity growth.

A Selected statistics by cohort

Birth cohort 1905-14

		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Obs.
1975	65	49041	41145	55289	33791	0.66	0.12	2.0	0.2	186
1976	66	48943	40373	58741	38078	0.69	0.17	2.0	0.2	177
1978	67	47069	30170	56447	34439	0.62	0.11	1.9	0.1	277
1979	69	43081	36624	51080	31194	0.66	0.14	1.8	0.1	179
1980	69	39513	24250	50368	30956	0.51	0.05	1.7	0.0	113
1981	70	39002	26022	51287	31029	0.59	0.07	1.7	0.1	143
1982	71	37844	23402	48667	29283	0.62	0.09	1.7	0.1	116
1983	71	34033	27815	46020	29296	0.67	0.14	1.7	0.0	98
1984	72	40719	21576	48638	25937	0.66	0.12	1.8	0.0	75
1985	72	32685	21867	49782	29611	0.65	0.02	1.7	0.0	72
1986	73	40963	24665	47941	24918	0.72	0.03	1.7	0.0	52
1987	73	53078	54559	50463	23795	0.81	0.05	1.8	0.0	34
1988	74	43067	28640	51881	21438	0.73	0.03	1.5	0.0	24

Birth cohort 1915-24

		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Observations
1975	55	65794	42338	70617	40203	0.73	0.17	2.1	0.7	255
1976	56	68368	41209	81605	37048	0.70	0.18	2.2	0.6	245
1978	59	62790	43974	72798	40597	0.66	0.13	2.1	0.4	407
1979	60	58642	40325	75382	40440	0.67	0.14	2.0	0.3	273
1980	61	52532	41311	62499	38622	0.63	0.14	1.8	0.2	196
1981	61	53297	39446	68981	38026	0.72	0.15	1.9	0.2	265
1982	62	52311	37237	64588	36756	0.72	0.12	1.8	0.2	245
1983	63	51845	39871	59444	34259	0.69	0.12	1.7	0.1	242
1984	64	52162	36407	60994	38140	0.71	0.11	1.7	0.1	229
1985	65	52394	34765	59937	33332	0.71	0.10	1.7	0.1	252
1986	67	54815	32798	64051	34329	0.79	0.11	1.7	0.1	211
1987	67	51869	34539	64462	36361	0.83	0.14	1.7	0.1	179
1988	68	49212	42710	60640	37005	0.80	0.07	1.6	0.0	188
1989	69	42649	29492	52490	27593	0.78	0.07	1.5	0.0	160
1990	70	45053	35165	56290	29884	0.79	0.06	1.6	0.0	169
1991	71	49632	43125	53939	28795	0.83	0.04	1.6	0.0	142
1992	71	49410	38501	59584	32815	0.81	0.07	1.6	0.1	81
1993	72	44448	26970	58620	25912	0.86	0.04	1.6	0.0	53
1994	72	51236	32203	64942	31003	0.93	0.09	1.6	0.0	51

Birth cohort 1925-34

		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Observations
1975	46	77217	40107	77406	36144	0.74	0.16	2.4	1.5	183
1976	47	82055	49716	86980	36291	0.69	0.14	2.3	1.5	191
1978	49	82516	51057	89678	40063	0.71	0.17	2.4	1.1	229
1979	50	81630	49345	89671	41640	0.74	0.22	2.4	1.2	236
1980	51	84006	80044	89181	40529	0.71	0.19	2.1	1.0	190
1981	52	83575	50563	92755	37591	0.72	0.17	2.3	0.8	244
1982	53	76705	41875	97067	42992	0.73	0.11	2.2	0.7	231
1983	54	79740	52893	86857	41468	0.76	0.13	2.2	0.7	259
1984	54	79469	53804	88329	42346	0.79	0.16	2.1	0.6	240
1985	55	78398	51346	89889	46647	0.81	0.12	2.1	0.6	203
1986	57	86606	60130	89823	45328	0.93	0.17	2.0	0.4	215
1987	57	90580	63114	97745	50702	0.92	0.13	2.1	0.4	183
1988	59	82509	55193	98313	49065	0.92	0.13	1.9	0.3	213
1989	60	72723	43784	85820	44973	0.93	0.15	1.9	0.2	162
1990	61	66063	44134	75116	40245	0.87	0.11	1.8	0.2	165
1991	62	62288	46084	74049	39927	0.89	0.08	1.8	0.2	157
1992	62	63557	41665	78718	43556	0.91	0.09	1.6	0.1	121
1993	64	59796	35968	76225	39410	0.86	0.06	1.6	0.1	132
1994	65	56969	37932	78724	40652	0.88	0.13	1.6	0.1	125

Birth cohort 1935-44

		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Observations
1975	35	75513	44660	73024	28942	0.57	0.14	2.0	1.9	181
1976	36	88561	58740	84053	27987	0.63	0.15	2.1	2.1	202
1978	38	85754	47854	82886	32354	0.63	0.13	2.1	1.9	189
1979	39	85456	42454	84338	33524	0.62	0.13	2.1	1.8	240
1980	40	82169	46420	85672	31446	0.66	0.14	2.0	1.6	179
1981	42	91726	48588	94751	35326	0.72	0.15	2.2	1.7	255
1982	42	88536	43479	96610	41034	0.72	0.18	2.2	1.6	249
1983	43	103357	53069	102229	41206	0.71	0.12	2.1	1.6	214
1984	44	106744	59041	101175	43504	0.77	0.15	2.2	1.4	219
1985	45	100003	61292	101635	44677	0.74	0.13	2.1	1.3	208
1986	46	106477	60952	107611	46761	0.92	0.14	2.2	1.1	233
1987	47	104638	60706	106602	51738	0.94	0.13	2.1	1.0	198
1988	48	106355	57444	125055	54751	0.91	0.19	2.2	1.0	225
1989	49	95553	54636	101478	43989	0.90	0.14	2.1	0.8	192
1990	50	92878	53658	102575	45815	0.94	0.15	2.1	0.7	192
1991	51	95511	66299	104667	49881	0.95	0.11	2.1	0.6	214
1992	52	92603	55224	105190	54433	0.88	0.14	2.0	0.4	247
1993	53	82568	49614	119620	119924	0.90	0.15	1.8	0.3	208
1994	54	93688	51415	120297	63622	0.94	0.15	2.0	0.4	201

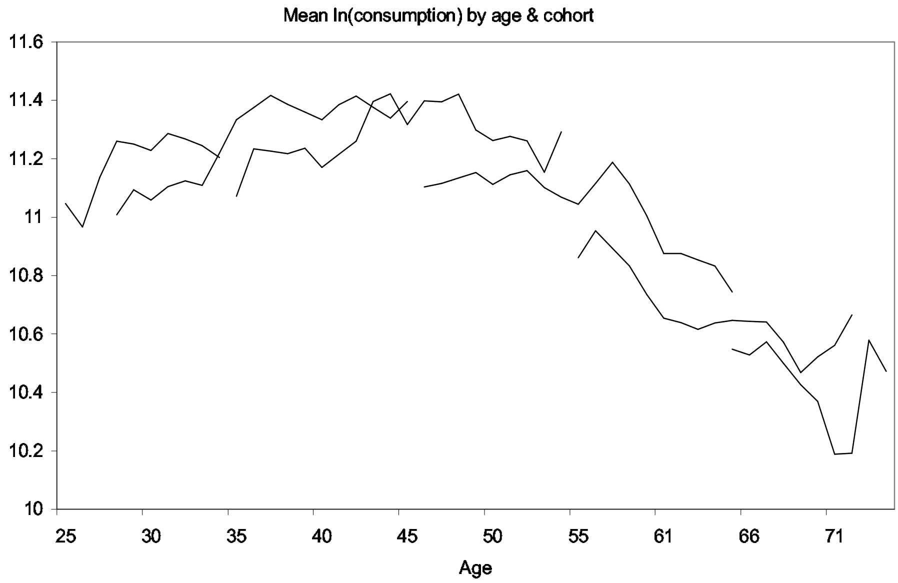
Birth cohort 1945-54

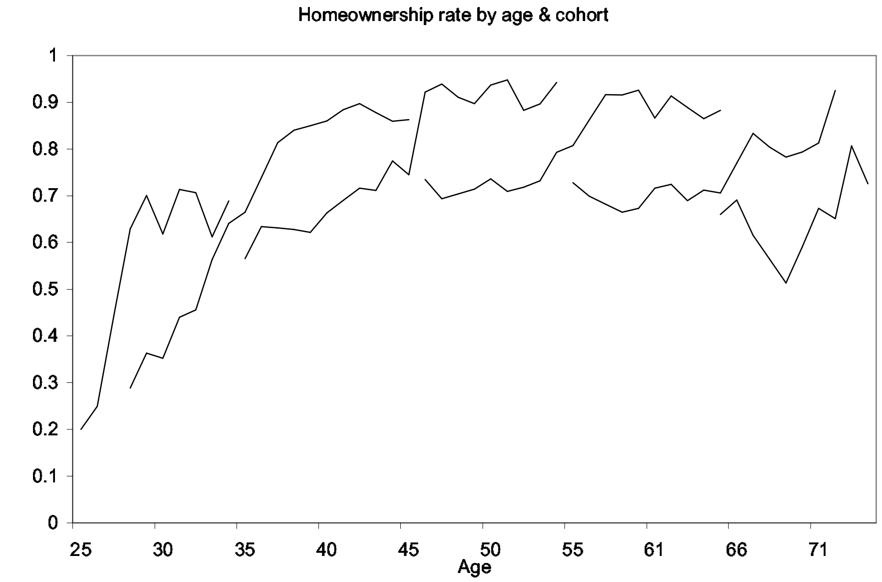
		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Observations
1975	28	68850	36199	65279	26786	0.21	0.09	1.8	0.9	97
1976	28	66007	28260	63519	24563	0.29	0.05	1.8	1.1	134
1978	29	74762	38559	75812	29265	0.36	0.14	1.9	1.3	202
1979	30	72356	43809	71341	28479	0.35	0.12	1.8	1.2	315
1980	31	75582	39642	78694	26890	0.44	0.10	1.9	1.3	241
1981	32	76119	40732	80813	30133	0.46	0.09	1.9	1.4	339
1982	33	74649	35013	80804	30050	0.56	0.14	1.9	1.5	319
1983	34	88435	45012	86404	32748	0.59	0.15	1.9	1.6	331
1984	34	85417	42580	85035	36266	0.64	0.13	1.8	1.5	346
1985	35	95324	48198	90806	37820	0.66	0.13	1.9	1.6	353
1986	37	105417	59075	97426	38032	0.81	0.14	1.9	1.5	342
1987	38	99486	52882	92909	37409	0.81	0.14	1.8	1.4	287
1988	38	103007	55442	117323	53087	0.84	0.14	1.8	1.4	347
1989	40	103458	52342	102722	39896	0.92	0.13	1.9	1.4	278
1990	40	96562	50116	103769	40919	0.86	0.07	1.9	1.4	243
1991	41	102902	56801	100567	40481	0.88	0.12	1.9	1.2	264
1992	42	106852	65512	111329	47595	0.90	0.13	2.0	1.4	389
1993	44	97525	53782	114338	52002	0.86	0.12	1.9	1.1	366
1994	45	101820	54400	119431	52766	0.86	0.12	1.9	1.1	377

Birth cohort 1955-64

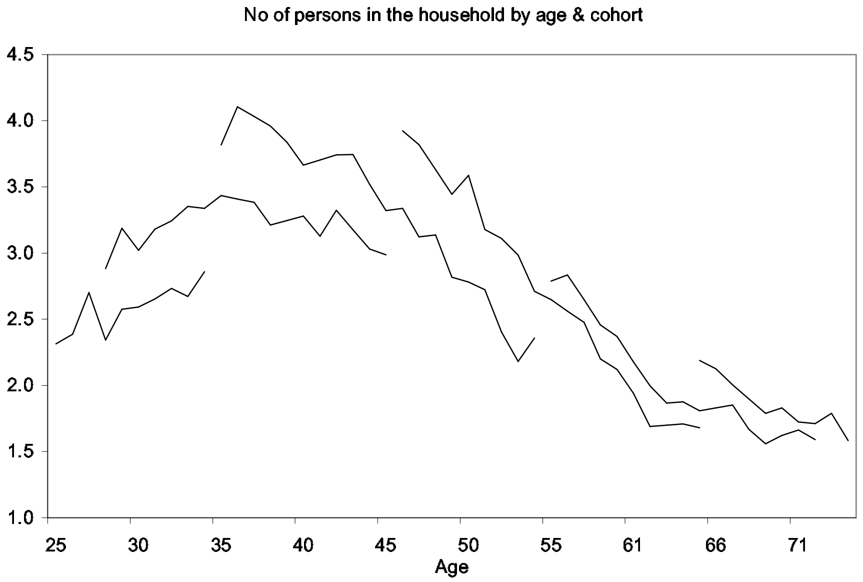
		Consumption		Labor income		Fraction of		Number of		
	Mean Age	Mean	Std	Mean	Std	Homeowners	Self-empl.	Adults	Children	Observations
1980	25	49170	20149	59525	17532	0.00	0.00	1.6	0.2	9
1981	25	72732	40095	69642	28316	0.20	0.03	1.7	0.6	58
1982	26	62475	24647	67920	31275	0.25	0.04	1.7	0.7	67
1983	27	72747	30170	70131	31039	0.31	0.06	1.7	0.7	107
1984	27	80718	49213	74213	31179	0.44	0.10	1.8	0.9	133
1985	28	87469	47001	82353	34662	0.39	0.10	1.8	0.9	198
1986	28	88515	46741	82220	35630	0.63	0.09	1.7	0.7	227
1987	29	94632	54958	83654	35197	0.75	0.10	1.7	0.8	195
1988	29	87277	44512	93719	45258	0.70	0.07	1.7	0.9	249
1989	30	88023	53289	84656	34811	0.62	0.04	1.7	0.9	242
1990	31	95008	49469	94856	39889	0.71	0.10	1.7	1.2	266
1991	31	92283	54482	86124	37925	0.71	0.10	1.6	1.0	311
1992	32	90584	49953	97246	42933	0.71	0.08	1.7	1.1	356
1993	33	90053	54200	95437	52997	0.61	0.09	1.6	1.0	356
1994	34	86009	49219	99875	65117	0.69	0.09	1.6	1.2	391

B Selected variables by age and cohort

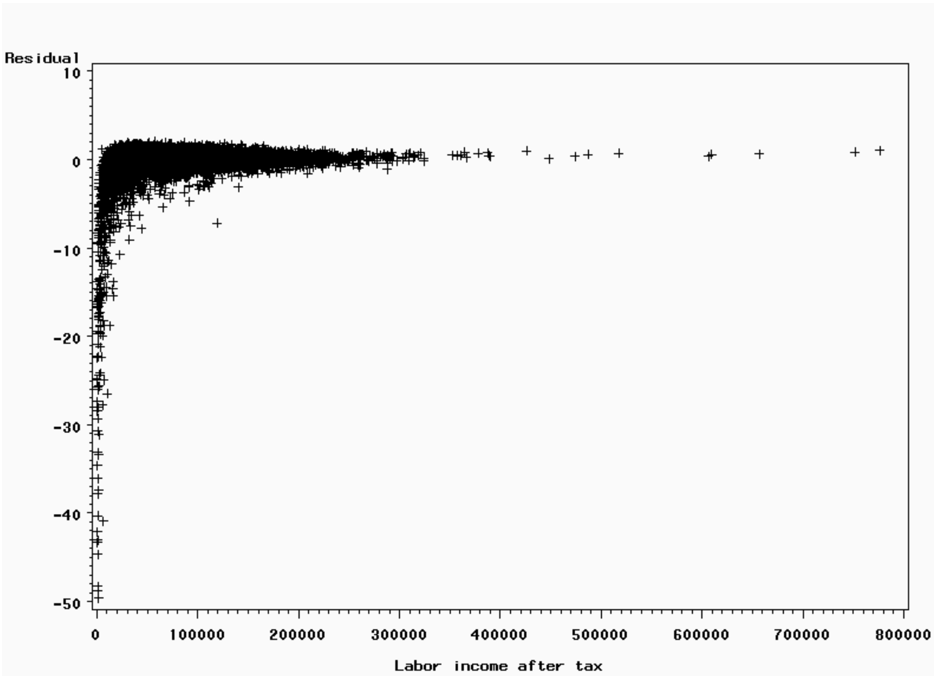



Homeownership rate by age & cohort
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
25
30
35
40
45
50
55
61
66
71
Age


Self-employed by age & cohort
0.25
0.20
0.15
0.10
0.05
0.00
25
30
35
40
45
50
55
61
66
71
Age

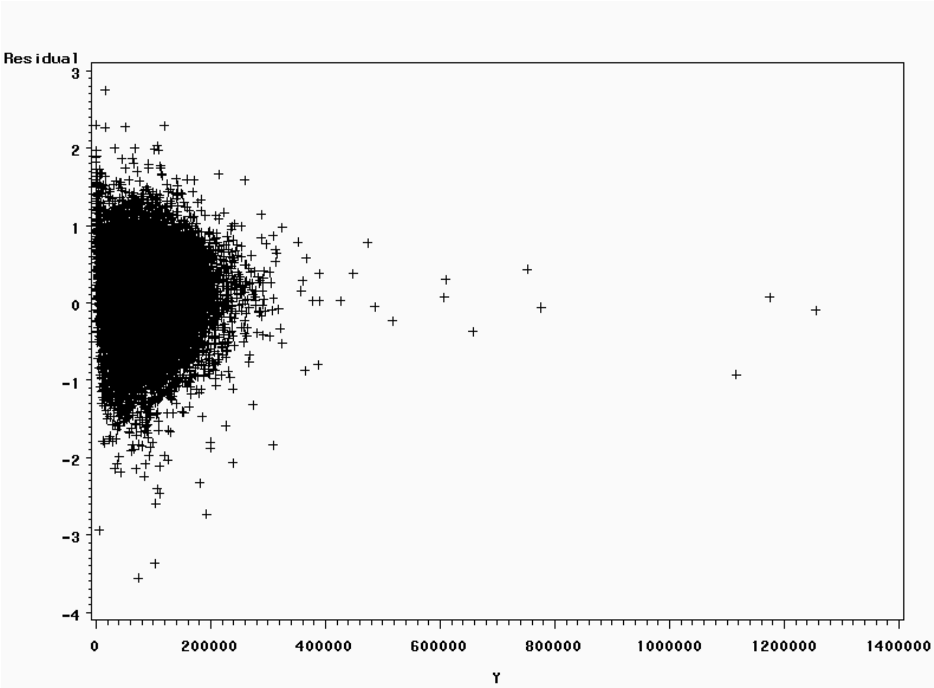

No of persons in the household by age & cohort
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
25
30
35
40
45
50
55
61
66
71
Age

C LS residuals, saving rate regression



Plot of residuals from the least squares regression of equation (11).

D LS residuals, ln consumption regression



Plot of residuals from the least squares regression of equation (19).

E Saving rate equation (11); full regression model (WLS and LTS)

	Model (2) WLS	Model (4) LTS
Intercept	0.597 (.026)	0.411 (.021)
$1/y_i$	-32719 (586)	-11920 (127)
Age of household head	0.002 (.001)	0.003 (.001)
$\text{Age}^2/100$	0.019 (.008)	0.016 (.008)
$\text{Age}^3/1000$	0.004 (.003)	0.007 (.003)
$\text{Age}^4/10000$	-0.005 (.003)	-0.008 (.003)
$\text{Age}^5/100000$	0.001 (.001)	0.002 (.001)
No of children	-0.092 (.005)	-0.099 (.005)
No of children^2	0.012 (.001)	0.014 (.001)
No of adults	-0.053 (.003)	-0.042 (.003)
Dummy variables:		
Birth cohort 1905-14	0.075 (.038)	0.045 (.034)
Birth cohort 1915-24	0.039 (.029)	0.020 (.028)
Birth cohort 1925-34	0.019 (.023)	-0.003 (.022)
Birth cohort 1935-44	-0.008 (.016)	-0.013 (.017)
Birth cohort 1945-54	-0.009 (.010)	-0.014 (.009)
Birth cohort 1955-64	0	0
Self-employed	-0.001 (.007)	0.015 (.007)
Self-employed spouse	0.013 (.009)	0.022 (.011)
Female head	0.037 (.007)	0.010 (.006)
Homeowner	-0.046 (.006)	-0.025 (.006)
Rural area (spars.pop.)	0.162 (.007)	0.151 (.007)
Rural area (dens.pop.)	0.058 (.006)	0.059 (.006)
January	0.114 (.009)	0.091 (.009)
February	0.074 (.011)	0.039 (.010)
March	0.066 (.010)	0.045 (.010)
April	0.069 (.011)	0.050 (.010)
May	0.037 (.011)	0.019 (.010)

(cont.)	Model (2)	Model (4)
June	0.010 (.011)	-0.014 (.011)
July	0.003 (.011)	0.002 (.011)
September	0.006 (.010)	-0.018 (.010)
October	-0.011 (.010)	-0.027 (.010)
November	0.003 (.011)	-0.009 (.011)
December	-0.136 (.011)	-0.101 (.011)
1977	-0.046 (.013)	0.035 (.011)
1978	0.026 (.013)	0.027 (.011)
1979	0.026 (.014)	0.007 (.011)
1980	0.047 (.015)	0.030 (.012)
1981	0.039 (.014)	0.032 (.011)
1982	0.072 (.014)	0.041 (.011)
1983	-0.010 (.014)	-0.022 (.011)
1984	-0.026 (.015)	-0.014 (.012)
1985	-0.042 (.015)	-0.103 (.012)
1986	-0.097 (.015)	-0.091 (.013)
1987	-0.087 (.016)	-0.002 (.012)
1988	0.010 (.015)	-0.079 (.013)
1989	-0.073 (.015)	-0.051 (.014)
1990	-0.040 (.016)	-0.073 (.014)
1991	-0.065 (.017)	-0.050 (.014)
1992	-0.053 (.017)	-0.028 (.014)
1993	-0.009 (.017)	0.000 (.015)
1994	0.003 (.018)	0.411 (.021)
AdjR^2	0.23	0.38
Breusch-Pagan	273.5	n.a.
χ^2 (2)	($<$ .0001)	
Kolmogorov-S	0.065	n.a.
(p-value)	($<$ .0100)	

Standard errors in parenthesis. The Breusch-Pagan tests the null hypothesis of homoskedasticity of covariates $1/y_i$ and $1/y_i^2$. The Kolmogorov-Smirnov tests the null hypothesis of normality of the standarized residuals. The dummies are normalized on a male household head, one who is a wage earner and residing in one of the major cities (Oslo, Bergen or Trondheim), born in the birth cohort 1955-64, and doing the the two weeks of consumer expenditure reporting in August.

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