Age Distributions and the Current Account — A Changing Relation?*

Thomas Lindh† and Bo Malmberg‡

October 22, 1999

Abstract

In recent research age distribution effects on the current account have been found in cross-country panel regressions. The reason is different effects on saving and investment from cohort-size variation. In a panel of annual OECD data 1960-1995, we find that the age effects on saving are similar to results on world samples but the effects on investment are very different. The respective age profiles of saving and investment are much more similar in the OECD sample. This may be one factor accounting for the home-country bias found in international capital markets. Disaggregating investment we find that young cohorts have a positive correlation with housing investment while older but still active cohorts have a positive correlation with business investment.The differences in saving and investment effects are, nevertheless, sufficient to generate persistent and sizeable age effects on the current account. Our results suggest that policies concerning current account balance should take into consideration age distributions and the degree of development.

Keywords: age distribution, home-country bias, saving, investment, current account, OECD

JEL Codes: E20, J10, O57

*We greatly appreciate useful comments from seminar participants at the Stockholm School of Economics, Uppsala University and the Workshop for Age Effects on the Macroeconomy, June 1999, in Stockholm. We are also grateful for ideas that emerged in several discussions with Jan Häggström and Mats Kinnwall.

†Department of Economics, Uppsala University, Box 513, SE-751 20 Uppsala, thomas.lindh@nek.uu.se, www.nek.uu.se/faculty/lindh, tel +46-18-471 1103, fax +46-18-471 14 78, mob +46-70-688 48 79.

‡Institute of Housing Research, Uppsala University, Box 785, SE-801 29 Gävle, bo.malmberg@ibf.uu.se, tel +46-26-420 65 12, fax +46-26-420 65 01, mob +46-708-26 11 05.

1 Introduction

In recent years, interest in the macroeconomic effects of changing population age distributions has been rising in many countries. New studies have shown that age effects are present in many different macroeconomic time series. In this paper we address one key issue in this line of research—the different effects of age structure on savings and investment, respectively, and consequently on the current account.

Higgins (1998) shows that in a world sample of countries the peak of positive age effects on investment comes from cohorts in their twenties or early thirties, while the positive saving effect is greatest for cohorts in their forties. This implies quite substantial variations in current account balances with changes in the age structure of the population. Higgins predicts that population ageing in the developed world should cause investment to decline more sharply than savings, thus exerting a favorable upward pressure on the current account and a general trend towards global capital abundance. Higgins and Williamson (1997) reach similar results, focusing on East Asia, and Taylor and Williamson (1994) argue a very similar point when explaining historical capital flows to the New World. Herbertsson and Zoega (1999) also report strong age effects on the current account and attributes a substantial part of this variation to variations in public saving.

In view of the rapidly changing age distributions in many industrialized countries this has far reaching ramifications for macroeconomic stabilization policies and exchange rate regimes. Policies aimed at current account balance as well as public budget balance may be seriously misguided and potentially harmful to economic efficiency, if these policies are working against market pressures emanating from variations in cohort size.

In this paper we show that estimations on annual and five-year OECD data also yield substantial age effects on the current account. The main difference to Higgins' results is that we find the peak positive age effects on investment in older age brackets than the positive effects on saving. The age profiles of the demographic effects on saving and investment that we find are more similar. Thus, there is somewhat less impact on the current account.

But the main difference is in timing. Our estimates would predict that population ageing will cause saving to decline before investment in the OECD countries, thus partly reversing Higgins' prediction of favorable demographic conditions for future current account balances in the developed world.

The main factor behind the different age pattern of investment effects is a significant positive effect from the upper middle aged cohorts on business investment. Higgins, as well as others, have argued that the positive investment effects from young cohorts in the world sample mainly are explained by labor force growth and maintained capital intensity.

We find that cohorts in their early twenties do have significant positive effects on housing investment but not on business investment. Our results suggest that, at least in the developed world, household formation and the demand for new construction is the most important mechanism for positive investment effects from growth in young adults. This mechanism is, however, dominated by positive effects on business investment from the middle aged in the OECD sample.

Age distributions in the industrialized world have large middle age cohorts while age distributions in the less developed part of the world are highly skewed towards younger cohorts. This difference in distribution is due to the fact that different countries have entered the demographic transition—to lower mortality and eventually lower fertility—at different times. Thus, the demographic transition and the investment results imply that economies during the transition to industrialization would be expected to display changing age effects on the current account in the course of deveopment.

Developing countries will have huge deficits as long as the population is dominated by large young cohorts. When fertility rates have decreased and the population starts ageing domestic saving will increase faster than investment demand and current account surpluses will arise. So far the story agrees with previous results in the literature. But as the population ages further and becomes dominated by middle-aged cohorts and young retirees saving will tend to decrease faster than investment and generate current account deficits again. In the OECD countries such a period will occur when the large post-war cohorts start to retire around 2010. Unless surpluses generated by emerging market economies are large enough to offset this tendency it would imply that a world-wide capital scarcity may emerge at that time.

Of course, these predictions are contingent on currency policies and other macroeconomic policy measures. If the tendency towards current account deficits is met with high-interest policies or trade-protection measures that depress the ratio of investment to saving, an actual deficit may never materialize. Strictly enforced budget balance restrictions in the OECD countries might also work in that direction. It is far from obvious that demographically induced deficits or surpluses in external and internal balances should be counter-acted by economic policy. These demographic effects are, therefore, a serious issue for the discussion around trade policies and exchange rate regimes. Our aim in this paper is, however, limited to provide some empirical facts to motivate such a discussion, not to actually initiate it.

Demographic effects on savings and the supply of capital has been much more in focus in economic research than the effects on investment demand. While there is an extensive literature about age effects on saving, very little research has been done on the age effects on investment. We, therefore, start in Section 2 with an examination of the savings evidence. In Section 2 we also present the data and discuss some econometric issues. Then we proceed to study the empirical investment patterns in Section 3. Summing up in Section 4 the implications for current account balances are spelled out and the repercussions on the economy are discussed. In Section 5 we sum up and conclude our argument.

2 Savings and age structure

Empirical analysis of cross-country aggregate savings data started with Leff (1967), Modigliani (1975) provides an early summary. Leff's results were criticized in the 1970's but more recent research has confirmed the existence of age effects on aggregate saving rates.[1] In spite of these results from aggregate studies, leading economists have questioned the importance of demographic change to explain shifts in the saving rate. Three main arguments have been advanced. First, in panel data the variation in age-specific saving rates over time is greater than the variation in the saving-rate across age groups (Bosworth et al.,1991; Poterba, 1994). Second, using given age-specific saving rates over the life cycle, movements in the population shares of different age groups are too small to account for observed movements in the saving rate (Bosworth et al.,1991). Third, the age effects on saving rates estimated on aggregate data only explain a small part of the variation in the saving rate (Bosworth, 1993).

Our results below show that at least the third argument is partially true. Age structure explains only a small part (less than 5 percent) of the short run variation in saving rates, but substantially more of the medium-run variation (around 20 percent). Per capita income growth is a much more important determinant of savings. This would seem to confirm the view held by the skeptics that age structure is a minor factor in macro-economic fluctuations. This skeptical conclusion is, however, premature for two reasons. First, income growth is in itself strongly affected by shifts in the age structure.[2] Second, even if age structure explains little of the short-run variation it does explain shifting trends in the saving rate quite well.

It is important to interpretation that consumption smoothing by households is only one venue for age distribution effects on national saving rates. Considerable parts of the national saving rate are the result of firm decisions taken directly in connection to an investment decision. Public saving—whether it is the result of direct political decisions or is caused by automatic responses in revenue or expenditure systems—is another important component of the national saving rate.

2.1 Sample and specification of age effects

In all estimations presented below we use cross-country panel data. This serves to alleviate problems with multicollinearity and omitted variables. Panel data offer a possibility to control for country-specific effects on saving and investment,

[1] See for example Mason (1987), Horioka (1999), Weil (1994), Kelley and Schmidt (1996), Higgins (1998), Miles (1999), and Lindh (1999).

[2] As shown in McMillan and Baesel (1990), Malmberg (1994), Lenehan (1996), Andersson (1998) , Bloom and Williamson (1998), Persson (1998), Bloom and Sachs (1998), and Lindh and Malmberg (1999) .

due to cultural and institutional differences, as well as time-specific effects due to variations in the world business cycle.

2.1.1 Data

A potential problem with panel data is parameter heterogeneity. If age effects differ between cross-sectional units biased or unstable parameter estimates may be the result. One way to alleviate this problem is to use a set of countries that are broadly similar in their institutional set-up and economic history. We use an OECD-only sample that should suffer less than a world sample from these problems.[3]

The OECD sample encompasses 20 of the OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany (BRD), Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Greece, Iceland, and Luxembourg were excluded after some experimentation because, not unexpectedly, they showed clear signs of being outliers as compared to the rest of the sample. Both Greece and Iceland have experienced extreme inflation episodes, as compared to the rest of the OECD, while Luxembourg's economy is tightly interwoven into those of its much larger neighbors. Turkey, Mexico, Hungary, South Korea and the Czech Republic were excluded beforehand due to lack of data.

In the basic estimations we use a full set of annual observations from 1960-1994. Economic data are taken from OECD National Accounts (1997), except for disaggregated investment data which are from OECD Economic Outlook. Annual demographic data are from United Nations (1994) starting in 1950. West Germany is an exception: the UN data refer to the population sum of East and West Germany so we obtained age structure data for West Germany

[3] Pesaran et al. (1996) discuss our type of panel with moderate time and cross-section dimensions and a lagged dependent variable finding that the standard fixed effects model may be subject to considerable estimation bias if there is parameter heterogeneity over countries. A simple remedy would be to estimate time series models for each country and then take the mean of the parameters as an estimate of the average effect. However, this mean group estimator assumes that the coefficients of the variables vary randomly across countries, see Swamy (1970). But in our case one may well suspect that the variation is systematic and dependent on other variables. One way to take account of systematic variation in coefficients over countries is explored in Higgins (1998) who interacts growth variables with the age groups, a specification based on Fry and Mason (1982) and Mason (1987) and often referred to as the variable-rate-of-growth model. A case might also be made that a comprehensive social security system acts as a substitute for saving. As a proxy government consumption can be interacted with age structure.

We made the experiment to derive age profiles of interaction specifications of the savings equation calculated using the mean growth rate and mean government consumption in the sample. These profiles were consistent with the patterns reported in this paper although the relative size of coefficients were highly sensitive to the interaction variables.

from Statistisches Bundesamt 1952 to 1996, which were used for the estimations. Since the age data refer to the 31 December in the given year, we have lagged them one step to ensure that they refer to the initial age structure of the year to which averages of economic variables refer. Since we lose one observation in calculating growth rates our estimation sample adds up to a total of 680 annual observations. When we use five-year data there are seven 5-year periods and thus 140 observations, from which we lose 20 when we include a period lagged dependent variable. Due to missing data in Economic Outlook the samples used for disaggregated investment were trimmed for some regressions to avoid inference problems with unbalanced panels.

2.1.2 Specification of age effects

Regression models with age variables differ in the way the age effects are specified. The basic problem is that all age groups cannot be included in the regression since multicollinearity would prevent identification of individual coefficients. Often, age effects are, therefore, represented by a single aggregate measure-for example population mean age, old age dependency rate (population share of people aged 65 and over), youth dependency rate (share of people aged 0-14) or total dependency rate (old age plus youth dependency rate). A weakness with this approach is that only a small part of the total age structure variation that might be relevant is used in the estimation of age effects. In particular, variations in economic behavior and economic resources that occur during the course of an agent's normal working life is ignored.

Another approach, pioneered by Fair and Dominguez (1991), is to use a polynomial restriction. The age profile of the demographic effects is then restricted to a low-order polynomial. This is also the approach of Higgins (1998)—see Appendix A for details. But—as will be apparent below—data may well reject the polynomial restriction.

A third way to represent the age distribution is to include population shares for a set of aggregated age groups that captures the most important phases of an individual's economic life cycle. In comparison to the single-measure approach this age share approach allows a fuller representation of the age structure. It also offers a more direct and flexible way of estimating age effects than the polynomial approach. Although we prefer this approach it should be noted that it is a compromise that may be sensitive to collinearity in some cases.

A subdivision into six age groups has been used: children 0-14 years old, young adults 15-29 years old, mature adults 30-49 years old, middle aged 50-64, young retirees 65-74 and old retirees above 75 years of age. This general division can be motivated on theoretical grounds even if the exact delimitation may be discussed. Children, first, do not take economic decisions themselves. Young adults often live single or are still living with parents. In OECD countries they are also to a high extent still studying and have quite distinct consumption habits. Mature adults are raising families, buying homes and starting in earnest to accumulate wealth. The middle aged are generally past their family years, have high incomes and are more immediately concerned with their retirement prospects. Young retirees are no longer working although still rather active and have started to dissave, at least in terms of their pension claims. The oldest have considerably more health problems and are more concerned with bequests.

To use the population shares as regressors we have to drop one group due to perfect collinearity with the intercept. Children is the most likely group to be simultaneously determined with the saving rate itself. We, therefore, chose to use that group as reference level.

2.1.3 Annual and 5-year data

We compare our results for the OECD sample with the results presented by Higgins (1998). He analyzes how age structure affects saving, investment and the current account balance in a world sample using both 5-year average data and 13-year averages. His data set is based on the Penn World Tables and UN population data with time series for 100 countries and complemented from other sources.[4]

There is a rather strong serial correlation in the dependent variables which is not accounted for by the independent variables. In studies focusing on the time series variation of individual countries the use of data with lower frequency than one observation per year is, in general, not an option. Increases in sample size due to pooling, however, allow panel studies to use data of lower frequency, for example averaged over five years or longer periods as Higgins do. This could be an advantage if annual data are noisy and is often routinely used with the motivation that it eliminates business cycles. However, in the presence of serial correlation, estimates based on, for example, five-year data should be treated with some caution, especially if time effects are introduced in the specification. The reason is that correlation between the averaged and accumulated disturbances and the likewise cumulated explanatory variables becomes much more likely by the time aggregation. In a dynamic panel this is further aggravated by the autoregressive dependent variable. Appendix B discusses these effects in formal detail.

We present estimates based both on annual data and on 5-year data. The reason is, first, that 5-year data have been used in previous studies and we want to compare with these results. Second, models based on 5-year data provide evidence of how the relatively slow-moving age variables affect the saving rate and investment rate over the medium run.

[4] We did check a world sample, too, using data from the World Bank (World Development Indicators). In this source data are available also after 1992. In other respects WDI is a poorer source than PWT. Time series begin only in 1970 as compared to 1950 in PWT and data are missing for many countries prior to 1980. However, our results on that sample were by and large similar to those of Higgins, so we did not explore this further.

Serial correlation both in saving rates and investment rates also raises specification issues. Our solution, below, to include the lagged dependent variable may be motivated by for example habit formation theories about saving and consumption which would work to slow down the adjustment to shocks, adjustment costs in new investment motivates the lag in an investment equation.

2.2 Saving regression results

The gross national saving rate is obtained by adding the current account balance (exports less imports with net factor income added) to gross investment and dividing by GDP, all in current prices.[5] For comparative reasons we have followed the parsimonious approach of Higgins (1998) with respect to inclusion of auxiliary variables. Thus, we include the GDP growth rate per capita and an indicator of the relative price of investment in both the savings and investment equations.[6] In the estimations the GDP growth rate per capita is the first difference of the logarithm of fixed price measures of current GDP less the rate of population growth computed as the log difference of average population in the year. The relative price of investment is defined as the implicit investment deflator (both fixed capital formation and stocks) divided by the implicit GDP deflator.

On theoretical grounds, a much broader range of economic variables could be considered.[7] However, in most cases we would encounter a simultaneity problem. Probably we have a simultaneity problem already with growth and the relative price of investment. Consistent estimates of these parameters would require in-

[5]Strictly speaking we should also add in private and public transfers but we wish to retain comparability with Higgins (1998) who uses this definition, claiming the differences are very small.

[6]There are several reasons why economic growth should have a positive effect in our regressions. First, a short-run positive growth effect on saving follows directly from the household's consumption smoothing. A second possibility is an accelerator effect on investment. Third, in life cycle theory, long-run increases in economic growth is likely to increase the aggregate saving rate since younger households will face a higher lifetime income and therefore need to save more in order to smooth consumption in old age. This effect is considerably less important for older households so the growth effect follows from aggregation.

The relative price of investment is included because it is part of the relative factor costs that should determine investment demand. High relative prices should tend to depress relative investment demand. Unless capital markets are perfectly integrated on the world market this would tend to spill over on savings, too. On the other hand high relative prices could also be caused by excess investment demand that would raise saving compensation and thus we might have an offsetting positive effect on saving. Thus a high relative price of investment could have a positive effect on saving but should tend to have a negative effect on investment demand. In practice these effects are hard to identify since we only observe the equilibrium outcome.

[7]We did attempt to use interest rates as a possible proxy for inflation expectations. Ex post saving is not the same as ex ante saving, so inflation could pose a problem. Nominal interest rates would be expected to reflect expectations of inflation. Considerably less complete observations were then available so results became more unstable and estimates more imprecise. The general pattern of the age coefficients remained robust though.

strumental variables. Good instruments are hard to come by, however, so we were content to check that IV estimates using lags—as instruments for growth and the relative price of investment—did not affect the age parameters much. These estimates are available on request but we do not report them here since our focus is on the age effects and we do not believe that the lags are really valid instruments

We control for country-specific and time-specific omitted variables. It is not self-evident, though, that these specific effects should be considered to be fixed. In the panel data literature it is generally asserted that if you wish to draw conclusions only about the sample at hand—and not about a more general population—fixed effects is the appropriate model to use, while random effects should be preferred in the converse case. In our case, using fixed country effects would thus be correct since we are interested in the age effects on savings in the OECD countries and how they may differ from those in more extended samples. In the time dimension, however, our interest goes beyond the sample period and, therefore, a random effects specification would be more appropriate. But random effects estimates are sensitive to misspecification so it is prudent to also consider fixed time effects. Fixed effects estimators are likely to be more robust in small samples (Kiviet, 1995).

We first present estimation results in Table 1 using both annual data and 5-year averages of economic variables and initial age shares. The regressions confirm the findings made by other researchers that there are significant age effects on the saving rate. Both estimates with fixed and random time effects are presented.[8]

The estimated age effects are broadly consistent with a life-cycle savings pattern, even though it is only the middle aged that have a significant positive effect on saving and the newly retired have a negative or zero effect. For the oldest age group there is a significant positive effect in the fixed time effects estimates. This is not altogether unexpected. It is a common finding in micro studies that the oldest tend to save substantially more than life cycle theory would predict. Even though some age coefficients are imprecisely estimated the tests for the importance of the group of variables as a whole consistently shows that the age group shares are statistically significant. For a life cycle explanation one would expect a clearer positive effect from the mature adults, since they would be expected to have positive net savings, but the signs of the young and mature adults are ambiguous in this table.[9]

[8]The standard errors of the OLS estimations are corrected to be robust to heteroskedasticity and autocorrelation, see Newey and West (1987). In annual regressions the correction allow for up to 6 lags, in 5-year regressions for lags of 2 periods. The residuals of our regression also show evidence of fat tails. We therefore computed minimum absolute deviations estimates, which are less sensitive to outliers, see Huber (1973) . This had little effect on the age group coefficients.

[9]Using inflation adjusted saving rates the mature adults have a statistically significant positive impact. The measure of inflation adjusted savings is based on a formal model in Lindh and Malmberg (1998). This measure implicitly assumes that unanticipated inflation is equal to

Dependent variable: National saving rates	Fixed time and country effects		Random time and fix country effects	
	Annual	5-year	Annual	5-year
No of obs	680	120	680	120
Growth	0.347	0.780	0.380	0.903
	(11.1)	(5.57)	(11.7)	(7.17)
Relative price of investment	0.003	0.032	-0.005	0.028
	(0.46)	(1.60)	(0.74)	(1.39)
Age group 15 to 29	0.019	0.148	-0.058	-0.120
	(0.46)	(1.19)	(1.93)	(1.19)
Age group 30 to 49	0.079	0.263	-0.045	0.030
	(1.68)	(1.96)	(1.09)	(0.22)
Age group 50 to 64	0.206	0.588	0.134	0.472
	(4.79)	(4.79)	(3.28)	(3.92)
Age group 65 to 74	-0.133	-0.410	-0.123	-0.777
	(1.58)	(1.46)	(1.51)	(2.89)
Age group 75 and above	0.357	1.248	0.046	0.430
	(3.19)	(3.97)	(0.59)	(1.67)
Lagged saving rate	0.746	0.343	0.776	0.462
	(25.5)	(4.20)	(27.7)	(6.09)
Adjusted R^2	0.698	0.309	0.825	0.425
$\chi^2(5)$ test of age var:	30.58	38.61	24.27	27.84
significance level	0.000	0.000	0.000	0.000

Table 1: National saving rates, autoregressive model, 20 OECD country sample 1960-1994. Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

Estimates on 5-year data yield much stronger age effects. The growth effect more than doubles, but although point estimates increase, the relative price of investment is still ambiguous. The magnitude of the age effects increases, in general by a factor of between two and four. This result is what we should expect if the annual model is correct, since persistent effects become accumulated over time by the lag of the dependent variable. The lag coefficient on the other hand diminishes to the level expected by computing the impact after five years using the annual lag coefficient. This is reassuring since it confirms what we would expect from the annual autoregressive model, see Appendix B. The joint significance of the age variables in the 5-year estimates is even stronger than in the annual model, in spite of the massive loss of degrees of freedom in the estimations.

The main difference in Table 1 is between fixed and random time effects. Neither of the estimators are unbiased since we have an autoregressive term.[10] The fixed time effects estimates are more in line with a life cycle pattern with positive effects from mature adults. The difference between random and fixed time effects estimates of the age pattern is to a large extent a shift in the base level, i.e. in the country- and time-specific intercepts.

In the random effects model the time-specific intercept is treated as random and estimated using the covariance matrix of residuals from an estimation with only country-specific effects. In the fixed effects model the time-specific intercept is treated as a deterministic constant. The random effects model is, therefore, more sensitive to any bias affecting the estimated covariance matrix in the first step. Since the first order impact of this is on the estimated intercepts, this may well shift the level of the coefficients. Allowing for a shift in base level, the differences in the pattern of the age coefficients are not very large.

2.2.1 A polynomial specification

Our way of specifying age effects by using a small number of age groups as regressors is not immune to multicollinearity problems. The polynomial approach is intended to alleviate that problem by restricting estimation to fewer parameters. Checking this also allows a direct comparison of our OECD results to those obtained by Higgins (1998) on a world sample.

Higgins (1998) finds powerful demographic effects on both national savings and national investment in a world sample. According to his estimates the in-

observed inflation. Crude though it may be the regression results were stabilized and less sensitive to outliers. But the general pattern was fairly similar to that reported below for national saving rates. We, therefore, abstain from presenting these results.

[10] As is well known, dynamic panel estimates are biased by the inclusion of the lag (Nerlove, 1971; Nickell, 1981). This particular bias is, however, inversely proportional to the number of time series observations for each cross-section unit. Since we have 34 usable time series observations this is hardly cause for much concern per se. But it does mean that we cannot use a Hausman test to choose between the two specifications since both estimators are inconsistent also under the null hypothesis.

Dependent variable:	Fixed effects				
National savings rate	Country		Time		Both
	OECD	*Higgins Table 1*	OECD	*Higgins Table 4*	OECD
No of obs	140	*580*	140	*258*	140
Growth	0.804	*0.378*	0.681	*0.454*	0.668
	(6.62)	*(5.50)*	(1.98)	*(2.10)*	(4.45)
Rel price of investment	-0.027	*0.183*	0.059	*-8.42*	-0.004
	(1.08)	*(0.09)*	(1.52)	*(6.13)*	(0.15)
Linear age coeff	-0.443	*1.54*	0.362	*0.825*	-0.0785
	(5.21)	*(1.87)*	(0.89)	*(0.77)*	(0.67)
Quadratic age coeff	0.061	*-0.0951*	-0.005	*0.0276*	0.020
	(4.49)	*(0.68)*	(0.07)	*(0.139)*	(1.05)
Cubic age coeff	-0.0024	*-0.000481*	-0.0012	*-0.00616*	-0.0009
	(3.87)	*(0.08)*	(0.40)	*(0.66)*	(1.13)
Adjusted R^2	0.549	*0.782*	0.364	*0.401*	0.115
$\chi^2(3)$ test of age var:	47.92	*25.01*	54.04	*28.39*	8.23
significance level	0.000	*<0.01*	0.000	*<0.01*	0.041

Table 2: Polynomial age effects restriction in a 20 OECD country sample 1960-1994, 5-year average economic data, age data refer to initial year in period. Comparison to results in Higgins (1998). Heteroskedasticity and autocorrelation consistent standard errors in OECD sample. Higgins' standard errors are corrected for heteroskedasticity. Absolute t-values in parentheses.

vestment stimulus is strongest from people around the age of 20, whereas the savings effect is stronger for middle aged people.

Are Higgins' results holding up in our OECD sample? In Table 2 and Figure 1 a direct comparison is made between Higgins' savings results[11] and the results obtained using 5-year OECD data with a polynomial restriction on age patterns. Two features stand out. First, we get considerably less stable and also weaker effects from the age distribution. Second, the savings pattern, although much weaker (note that the scale is different in the last panel of Figure 1), is similar except when only country-specific effects are taken into account. However, the peak saving effect is at age 50 rather than at 35-39 as found by Higgins.

The individual significance of the age variables is lost in Table 2 when time effects are included. The age variables are, however, jointly significant in all cases. Except for the growth effect Higgins' estimated coefficients are generally of a higher magnitude. Higgins use growth per worker while we use growth per capita, but that hardly explains the difference in coefficient magnitudes.

A clue to part of the difference is apparent in the third panel of Figure 1. The effects estimated with the age share approach are considerably larger in magnitude.[12] While the span of the polynomial impact in panel 3 of Figure 1 is only about 0.5, the span in the age share coefficients is over 2.5. This is still smaller than Higgin's polynomial span of 5 or more, but much more comparable. The conclusion is, thus, that the smoothing of especially the effects of the three oldest age groups imposed by the polynomial restriction explains much of the difference.

The polynomial approach actually generates much more serious multicollinearity (!) among the compounded age variables than we get with the age share variables. The three compounded age variables used in the estimations are very highly correlated in our sample. Amost all partial correlations are around 0.98-0.99. This makes it difficult to obtain reliable estimates of the individual coefficients, since these are liable to be magnified and even shift signs. This is especially troublesome with respect to the cubic term since the age profile is extremely sensitive to changes in this parameter. For comparative reasons the lag of national saving rates is not included in these regressions and thus the residuals are quite highly autocorrelated, but recall that standard errors are corrected for that.

[11] Note that Higgins' fixed country effects model is estimated on 5-year data, while the corresponding time effects model (which he calls the pooled model) is estimated on 13-year periods.

[12] The coefficient for the children is estimated by imposing the restriction that all age group coefficients should sum to zero, a restriction which is also implicit in the implementation of the polynomial restriction.

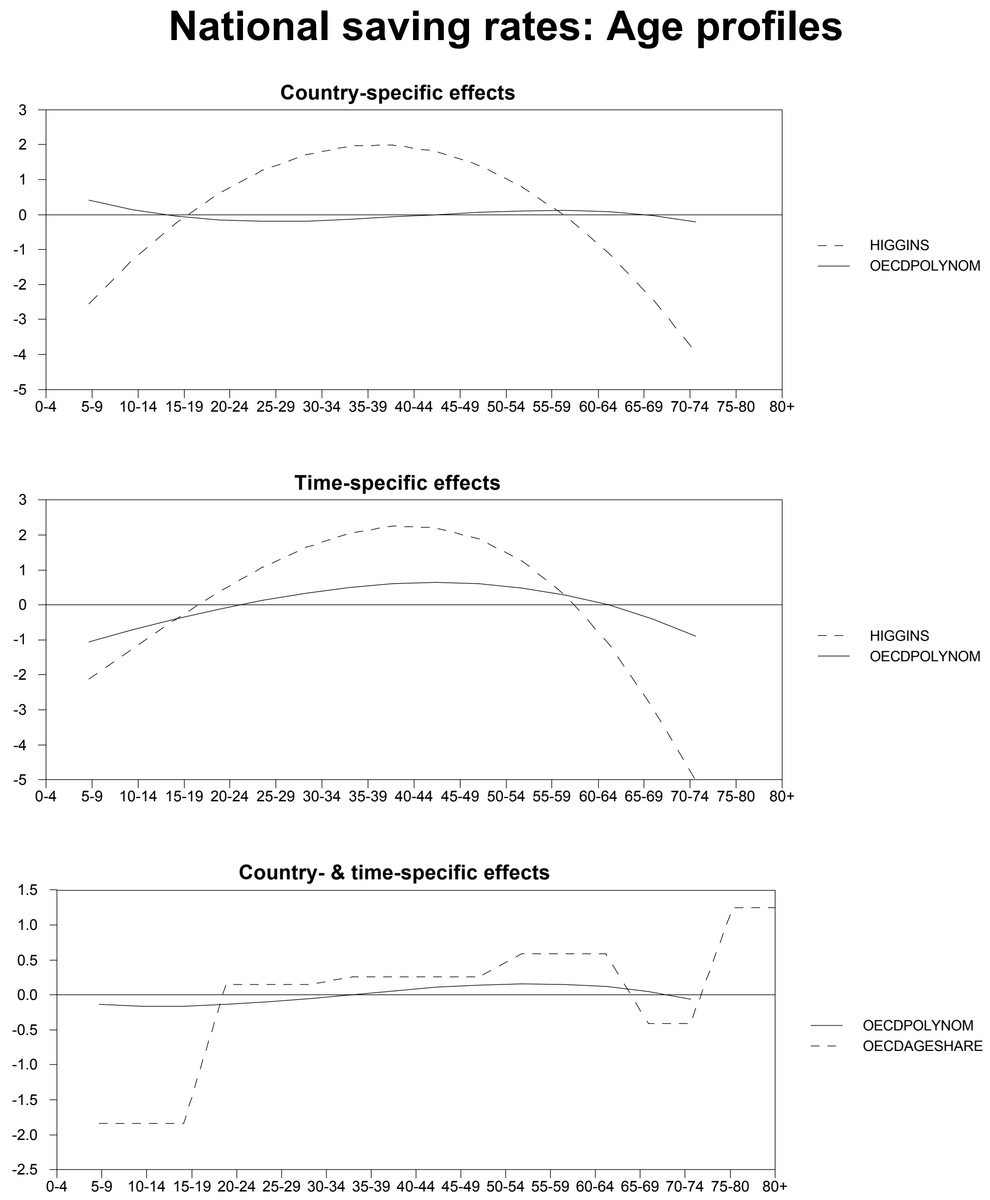

Figure 1: Age patterns comparing Higgins' polynomial restriction estimates with the OECD patterns in the two upper panels. The third panel compares the polynomial restriction pattern with the age share pattern in Table 1, column 2.

3 Investment and the age structure

The discussion about age effects on investment in the literature has no similarly distinguished history as the age effects on savings. Although there has been a somewhat lively debate on age distribution effects on house prices[13], the implication that housing investment should respond to demographically induced price changes has not been generally recognized in the macroeconomic literature. Although planning authorities have always taken the demographics of household formation into account economists have been rather skeptical, see e.g. Meen (1998).

But there are also other venues for age effects on investment: an inflow of young workers requires new investment in equipment to maintain capital intensity; increased productivity through learning-by-doing implies that an increased proportion of older workers substantially decreases the ratio between capital and effective labor, thus stimulating new investment. The portfolio shift from real towards financial assets—that is observed as people get around 50 years of age and start to prepare for retirement—would also stimulate investment by making equity financing of investment easier and cheaper. Public investment on the other hand should be tied to the dependency burden. Children require schools, elderly health care in hospitals or other publicly financed services.

In Table 3 we report the same set of estimations as for savings in Table 1. The growth effect is—somewhat surprisingly—not stronger on investment than on saving, and in the 5-year estimates actually considerably weaker. The relative price of investment is ambiguous or positive. The lag of the investment rate in Table 3 has lost significance in the 5-year estimates, and diminished much more than expected from the annual estimates. There is, thus, reason to suspect that endogeneity may be more of a problem with investment than with saving. Instead of catching movements along the demand curve we may actually be observing shifts in investment demand along the supply curve of saving that causes the relative price to rise with measured investment. This is hardly unexpected on annual data where a substantial part of the variation is on the business cycle frequencies, but it is actually strengthened when we use 5-year data. Appendix B demonstrates why endogeneity bias should become more serious by time aggregation. It also implies that using lags as instruments is unlikely to be effective in getting rid of endogeneity bias.

Point estimates for both young and mature adults tend to be negative. All these estimates are insignificant, however, and the only significant estimate for age group 15-29 is strongly positive. On the other hand the signs of the two oldest groups tend to reverse as compared with the savings pattern. The effect of middle aged is stronger and quite precisely estimated. The significance of the

[13] See Mankiw an Weil (1989) and the ensuing debate in *Regional Science and Urban Economics*.

Dependent variable: Gross investment rates	Fixed time and country effects		Random time and fix country effects	
	Annual	5-year	Annual	5-year
No of obs	680	120	680	120
Growth	0.537	0.226	0.536	0.387
	(16.1)	(1.04)	(16.5)	(1.92)
Relative price of investment	0.008	0.071	0.008	0.061
	(0.88)	(2.85)	(0.83)	(2.65)
Age group 15 to 29	-0.038	0.301	-0.027	-0.028
	(0.94)	(2.77)	(0.77)	(0.24)
Age group 30 to 49	-0.022	0.055	-0.053	-0.257
	(0.46)	(0.36)	(1.03)	(1.75)
Age group 50 to 64	0.235	0.596	0.210	0.448
	(4.69)	(3.37)	(4.43)	(2.83)
Age group 65 to 74	0.001	0.477	0.086	0.047
	(0.01)	(1.66)	(0.99)	(0.20)
Age group 75 and above	0.011	0.184	-0.001	-0.930
	(0.06)	(0.29)	(0.01)	(2.08)
Lagged investment rate	0.798	0.170	0.799	0.163
	(26.9)	(1.60)	(27.3)	(1.49)
Adjusted R^2	0.714	0.144	0.745	0.368
$\chi^2(5)$ test of age var:	31.26	22.50	25.61	22.72
significance level	0.000	0.000	0.000	0.000

Table 3: Gross investment rates, autoregressive model, 20 OECD country sample 1960-1994. Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

Dependent variable:	Fixed effects				
Gross investment rate	Country		Time		Both
	OECD	*Higgins Table 1*	OECD	*Higgins Table 4*	OECD
No of obs	140	*580*	140	*258*	140
Growth	0.300	*0.328*	1.006	*0.369*	0.226
	(1.71)	*(5.18)*	(3.28)	*(2.68)*	(1.00)
Rel price of investment	0.051	*-4.50*	0.040	*-3.30*	0.065
	(1.65)	*(2.95)*	(1.14)	*(4.01)*	(2.12)
Linear coeff	-0.373	*3.25*	-0.299	*2.70*	-0.143
	(3.40)	*(3.91)*	(1.03)	*(4.26)*	(0.80)
Quadratic coeff	0.049	*-0.511*	0.068	*-0.393*	0.030
	(3.21)	*(3.62)*	(1.52)	*(3.55)*	(1.10)
Cubic coeff	-0.0019	*0.0206*	-0.0035	*0.0147*	-0.0015
	(3.11)	*(3.36)*	(1.85)	*(2.90)*	(1.27)
Adjusted R^2	0.462	*0.583*	0.227	*0.255*	0.033
$\chi^2(3)$ test of age var:	35.59	*20.08*	11.58	*24.88*	4.15
significance level	0.000	*$<$0.01*	0.009	*$<$0.01*	0.246

Table 4: Polynomial age effects restriction in a 20 OECD country sample 1960-1994, 5-year average economic data, age data refer to initial year in period. Comparison to results in Higgins (1998). Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

group of age variables is not in doubt in this case either.

The polynomial restriction estimations reported in Table 4 and Figure 2, show that the age profile becomes more or less the inverse of Higgins'. He finds a peak positive effect around 20 while we find a negative minimum in age brackets close to this. His minimum around 60 corresponds to maxima around 50.

The age variables, however, lose joint significance when we include both time- and country effects. The low adjusted R^2 indicate that the polynomial restriction is rejected by the data in this case. The corresponding age share estimate in column 2 of Table 3 is much more secure, even if adjusted R^2 is a bit low in that case, too. Again we see a span of age effects that is much more comparable to Higgins' results when we use age shares rather than the polynomial restriction. It remains clear, however, that our investment equations give a radically different age profile in the OECD sample as compared to Higgins' world sample.

The main question these estimates give rise to is then: Why are there such large differences between Higgins' estimates and the OECD estimates when it comes to investment rather than saving?

3.1 Age effects on disaggregated investment

At least two hypotheses could be put forward to explain Higgins' age pattern of investment. One is that inflow into the labor force stimulates new investment to keep the capital-labor ratio up. The other is that young people in the ages where household formation takes place require very substantial construction investment in order to obtain housing.

To check whether both or only one of these explanations are consistent with our data we ran the same regression equations but using components of aggregate investment as dependent variables. The results are reported in Table 5.[14] The age variables have very distinct effects on the components of investment (except government investment) but with different patterns. According to Table 5, two age groups have significant positive effects on housing investment; young adults on the one percent level and middle aged on the 5 percent level. Private business fixed investment, on the other hand, is significantly boosted only by the middle aged, 50-64 years.

[14]The disaggregated investment data from Economic Outlook were trimmed, Portugal lacked data except for total fixed investment, and the Netherlands lacked data for 1960-1968 to subdivide private investment into business and housing investment. Several countries also lacked data for the first years in the 1960s. We have also checked that data conform to the convention that total investment less government investment equals private investment, which in turn equals the sum of business and housing investment. In two cases (the first decades for Italy and Canada) we made corrections, and in two other cases we imputed missing private investment data (the whole series for the United States and the 1960s for the Netherlands). 1991 and forward data for the unified Germany seems to have been just added to the older West German series, but attempts to correct for this had only minor impact so we abstained from correction in this case.

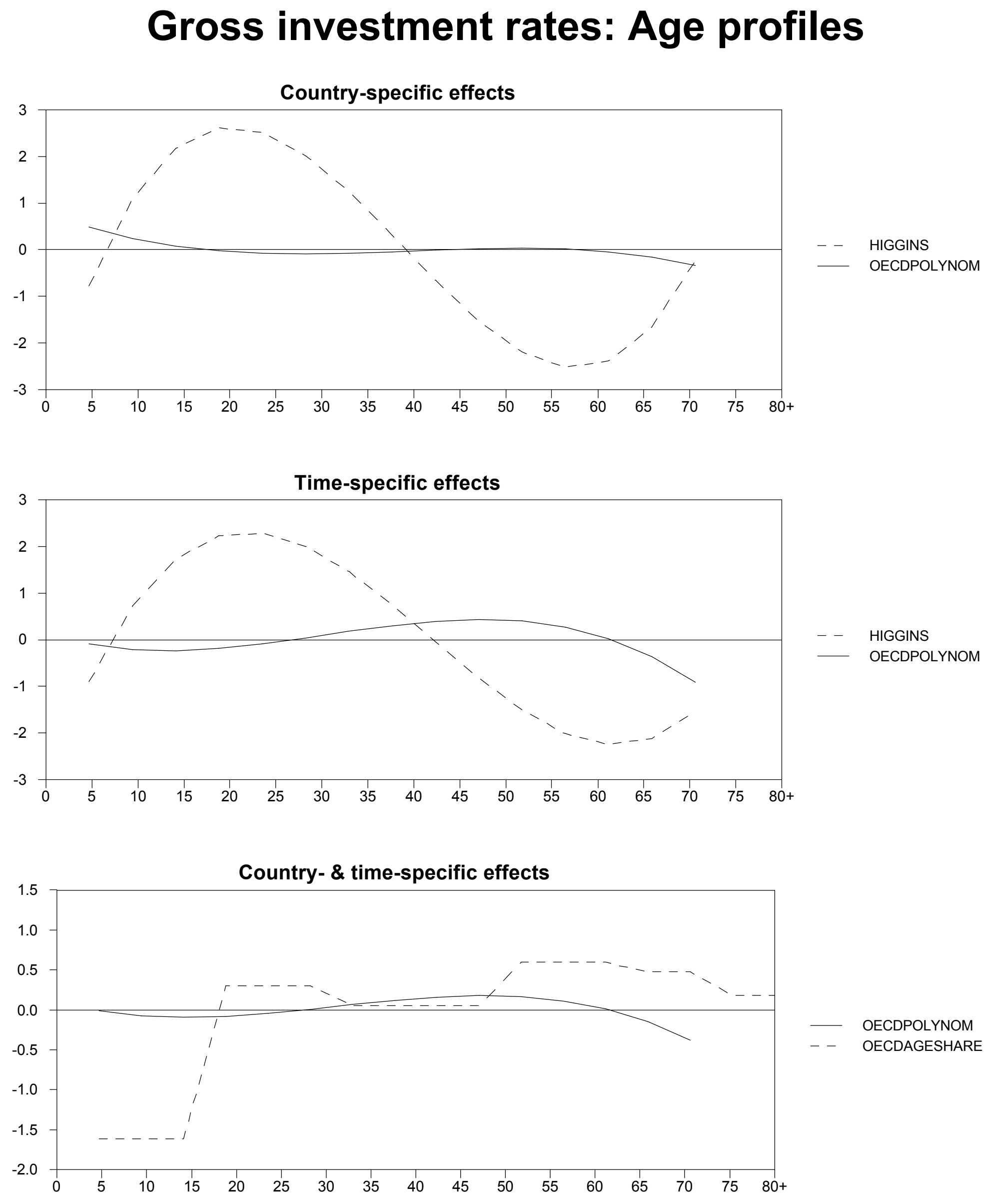

Figure 2: Age patterns comparing Higgins' polynomial restriction estimates with the OECD patterns in the two upper panels. The third panel compares the polynomial restriction pattern with the age share pattern in Table 3 column 2.

Dependent variables: Investment rates	Gross fixed (excl. stocks)	Private gross fixed	Gov. gross fixed	Private business gross fixed	Housing
No of obs	680	570	570	540	540
Growth	0.201	0.240	-0.016	0.172	0.068
	(6.34)	(8.27)	(1.86)	(6.60)	(5.81)
Relative price of invest.	-0.029	-0.029	0.003	-0.024	-0.010
	(3.10)	(3.28)	(1.15)	(2.93)	(3.02)
Age group 15 to 29	0.070	0.064	0.015	0.022	0.050
	(2.19)	(1.80)	(0.88)	(0.71)	(2.69)
Age group 30 to 49	0.033	0.087	-0.011	0.053	0.036
	(0.81)	(1.88)	(0.47)	(1.17)	(1.14)
Age group 50 to 64	0.198	0.207	0.023	0.167	0.059
	(4.64)	(3.98)	(1.25)	(3.55)	(2.00)
Age group 65 to 74	-0.010	-0.077	0.047	-0.063	-0.009
	(0.12)	(0.87)	(1.30)	(0.86)	(0.22)
Age group 75 and above	0.077	0.094	0.058	0.131	-0.062
	(0.51)	(0.80)	(1.18)	(1.38)	(1.08)
Lagged investment rate	0.856	0.860	0.889	0.816	0.847
	(22.8)	(22.2)	(35.0)	(17.6)	(39.42)
Adjusted R^2	0.795	0.774	0.799	0.718	0.770
$\chi^2(5)$ test of age var:	26.87	19.08	6.61	17.13	13.24
significance level	0.000	0.002	0.251	0.004	0.021

Table 5: Investment rate components. OECD 18-20 countries, annual sample between 1960-1994. Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

The middle aged have a consistently positive effect on private investment as a whole. One hypothesis could be based on the fact that this age group tends to transfer wealth from real assets to financial assets (see for instance Skinner 1989). This process is likely to decrease the local cost of capital because of home bias in equity. Another hypothesis is that the middle aged due to experience are more productive and thus lower the effective capital intensity. Unless this is fully cancelled by higher wage costs it will also decrease the relative cost of capital. Note that these hypotheses are complementary since they both work to decrease the relative cost of capital. Our study, thus, cannot distinguish between them. Previous work on growth regressions lend support to the latter—Malmberg (1994), Lindh and Malmberg (1999)—who find this positive productivity effect from the middle-aged. However, this does not exclude a separate effect via the other mechanism. In fact, Lindh (1999) shows that in a simultaneous equation model the age effects on savings and growth appear to be more or less independent.

The age effects on government fixed investment are dominated by the oldest age groups but here the demographic effects are statistically insignificant.[15] The only well defined (significant on the ten percent level) effect from the oldest age group is a negative one on housing investment. This is not unexpected since studies of age effects on house prices generally find a negative effect from this group. It is consistent with the idea that they are selling off their houses, moving to apartments and nursing homes. Increasing mortality with age also contributes. Each person who dies frees a slot in the housing market without requiring new investment.

We could also note that the relative price of investment have significant negative effects on all components of investment except public investment. This leads us to conjecture that the endogeneity problem with this variable is mainly associated with adjustments of inventory stocks—which are excluded in Table 5, but not in Tables 3 and 4.

4 The current account

The difference in age structure impacts on investment and saving translates into an age effect upon the current account, too. Since this effect reflects temporary imbalances in the economy which corresponds to real behavioral differences among age groups, there is no prima facie case for economic policy to intervene to correct these imbalances. A country borrowing from abroad to finance investment demand generated by an age structure with relatively more young retirees than middle aged in the population is not facing a long-run imbalance. After a decade or so the relation is likely to reverse as yesterday's young retirees become today's old retirees, and the relatively sparse middle-aged cohorts replace them as young

[15] That does not imply that the public sector is unimportant for these effects, but the influence may be channeled through the budget balance, rather than accounted fixed investments.

retirees. But, since "temporary" on this time scale is a matter of decades many economists and politicians will believe that they have been caught in a long-run dependence on foreign capital. Fixed exchange rate regimes will also get into trouble since decadal trend changes in inflow and outflow of currency are hard to accommodate.

In Table 6 we report the estimates with the age share approach. This essentially repeats the information already presented in previous tables since the dependent variable is the difference between saving and investment. But the information is in a more accessible form. Joint significance for the age variables on traditional 5 percent levels holds only for the 5-year estimates and the fit is worse than for savings and investment separately.

However, in Table 6 an age pattern emerges where mature adults and the oldest have positive effects on the current account while in particular the young retirees have a strong negative effect. This reflects the differences in investment and saving patterns with positive savings effects for groups with negative or neutral investment effects translating into positive current accounts effects and vice versa. The middle aged who boost both savings and investment, however, has a neutral effect on the current account. Because of these cancellation effects it is the age distribution among the retired people which is most important for the current account effects.

It is tempting to conjecture from these results that the increased demand for health care among the oldest is a driving force behind both the current account effect and the positive effect on savings. Health care services are to a large extent non-tradable. A shift in demand towards non-tradables should translate into improved current account balances and consequently increases in the national saving rates, ceteris paribus. However, that must be left for further research to investigate.

In Table 7 and Figure 3 we report the current account results when we impose a polynomial restriction. The weak and unstable effects indicate that the polynomial restriction is too harsh on the data. Only in the case with time effects and no country effects do the age variables achieve joint significance, and in that case we also get a very different pattern from Higgins with the main positive effects from young adults. But the polynomial restriction is unable to accomodate the strongly different effects from the two oldest age groups and averages these to a more or less neutral effect.

The spread of the age coefficients in Figure 3 is well below 0.5 if we disregard the children effect in the mid panel, but using age shares we again obtain a more considerable spread and thus a greater impact on the current account. The age share estimates seem overall more reliable so in relation to Higgins' predictions we, thus, would predict worsening of the average current accounts in OECD as postwar baby booms start to retire in the beginning of the next millenium but some decade later they will grow older and induce a recovery at about the time when Higgins' would expect a worsening.

Dependent variable: Current account/GDP	Fixed time and country effects		Random time and fixed country effects	
	Annual	5-year	Annual	5-year
No of obs	680	120	680	120
Growth per capita	-0.186	0.523	-0.167	0.358
	(4.74)	(2.21)	(4.58)	(2.23)
Relative price of investment	-0.005	-0.041	-0.009	-0.051
	(0.50)	(1.30)	(0.83)	(1.71)
Age group 15 to 29	0.043	-0.104	-0.031	-0.184
	(0.90)	(0.74)	(0.76)	(1.68)
Age group 30 to 49	0.101	0.229	0.052	0.135
	(1.49)	(1.15)	(0.81)	(0.71)
Age group 50 to 64	-0.040	0.009	-0.050	-0.149
	(0.63)	(0.04)	(0.96)	(0.99)
Age group 65 to 74	-0.146	-0.792	-0.274	-0.795
	(1.21)	(2.38)	(2.46)	(3.04)
Age group 75 and above	0.364	1.086	0.118	0.716
	(1.41)	(1.33)	(1.01)	(2.39)
Lagged current account	0.782	0.176	0.785	0.249
	(20.7)	(1.56)	(20.6)	(2.47)
Adjusted R^2	0.607	0.126	0.603	0.388
$\chi^2(5)$ test of age var:	10.16	17.04	9.10	30.97
significance level	0.071	0.004	0.105	0.000

Table 6: Current account balance, autoregressive model, 20 OECD country sample 1960-1994. Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

Dependent variable: Current account/GDP	Fixed effects Country OECD	*Higgins Table 1*	Time OECD	*Higgins Table 4*	Both OECD
No of obs	140	*580*	140	*258*	140
Growth	0.504	*0.05*	-0.325	*0.0701*	0.442
	(2.57)	*(0.07)*	(1.47)	*(0.34)*	(1.84)
Rel price of investment	-0.078	*-4.32*	0.019	*-5.13*	-0.068
	(2.17)	*(2.04)*	(0.62)	*(4.06)*	(1.81)
Linear coeff	-0.070	*-1.71*	0.661	*-1.85*	0.064
	(0.85)	*(2.04)*	(2.16)	*(1.86)*	(0.37)
Quadratic coeff	0.012	*0.416*	-0.072	*0.414*	-0.011
	(1.00)	*(2.86)*	(1.56)	*(2.22)*	(0.40)
Cubic coeff	-0.0005	*-0.021*	0.0024	*-0.0205*	0.0006
	(0.83)	*(0.03)**	(1.20)	*(0.02)**	(0.48)
Adjusted R^2	0.128	*0.696*	0.327	*0.214*	0.050
$\chi^2(3)$ test of age var:	5.21	*20.87*	36.98	*16.58*	2.88
significance level	0.157	*<0.01*	0.000	*<0.01*	0.411

Table 7: Polynomial age effects restriction in a 20 OECD country sample 1960-1994. 5-year average economic data, age data refer to initial year in period. Comparison to results in Higgins (1998). Heteroskedasticity and autocorrelation consistent standard errors. Absolute t-values in parentheses.

*This may be misprints. The coefficient is marked as 1% and 5% significant, respectively, although the absolute t-statistic is given as 3.26e-2 in the first case and 2.36e-2 in the second.

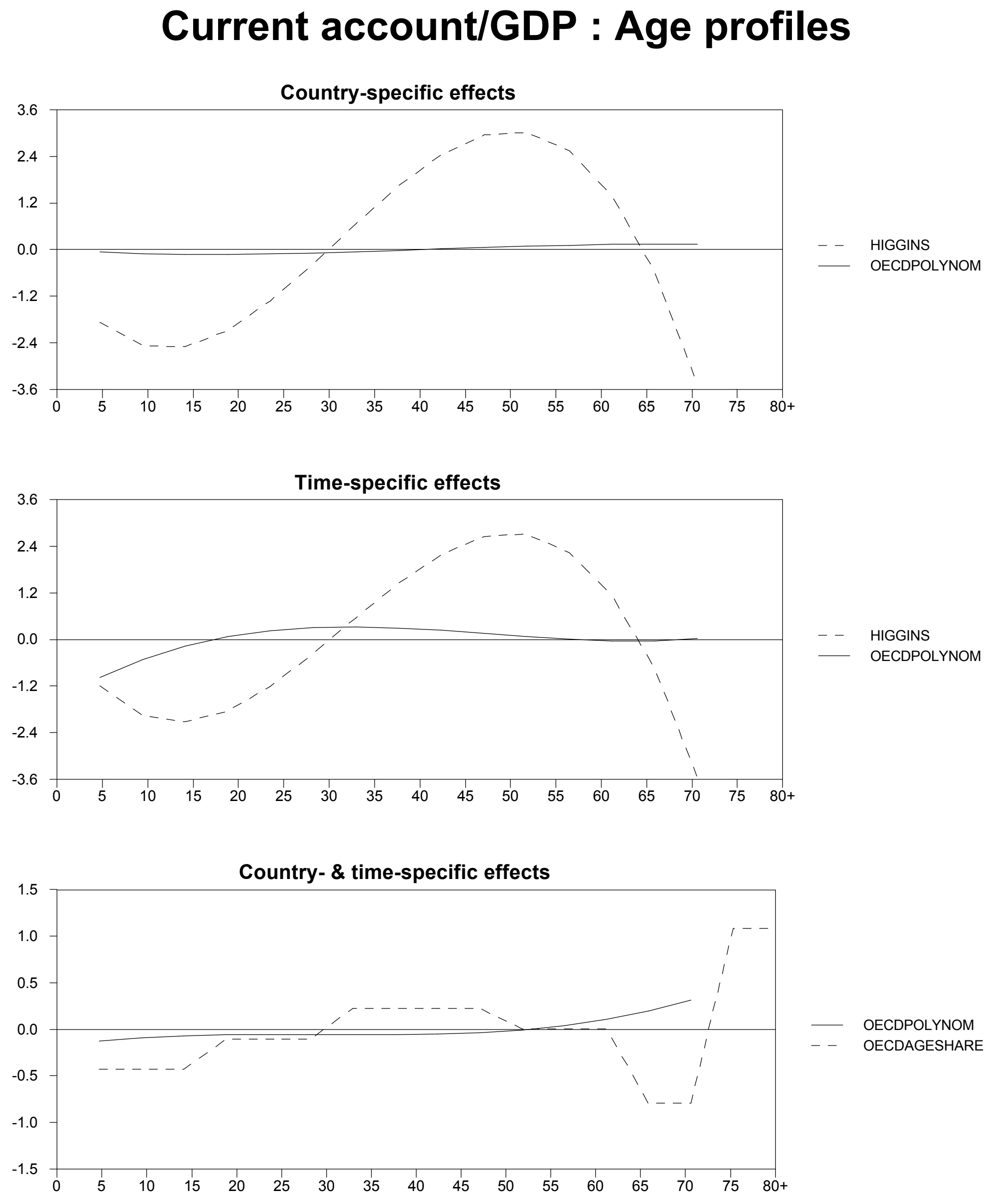

Figure 3: Age patterns comparing Higgins' polynomial restriction estimates with the OECD patterns in the two upper panels. The third panel compares the polynomial restriction pattern with the age share pattern in Table 6 column 2.

The impact of the age distribution on the current account is not directly implied by the coefficients, since the growth of one age share is always accompanied by decreases in other age shares. We have to take the movement in the whole distribution into account and also compensate for the fact that mortality naturally dampens the increase in older age groups.

To give some feeling for the impact that ageing will have on the OECD countries current account balances we have computed the average impact of future five-year changes in the age shares as projected by UN (1994). In Figure 4 the two panels graph the implied direct impact of age distribution changes, ignoring the feed-back through the lag. The upper panel with fixed time effects give a somewhat more optimistic view of future impacts using the estimates in coulmn 2 of Table 6. The random effects estimator in column 4 of Table 6 differs mainly with respect to the base level. But the direction of change is consistent in both cases and it is mainly the difference in the intercepts of the two equations that accounts for the shift in impact pattern.

In the computation we have used the assumption that the age coefficients sum to zero in order to recover the impact of children. Although this is a conventional way to do it, we are not quite comfortable with it. In fact the assumption implies that a uniform distribution will have zero effect which is rather ad hoc. The baseline of zero impact in the graph thus should not be too literally interpreted. It is the pattern of an upward demographic pressure in the next five years that is then replaced by a sustained downward pressure that is of importance. The projections for the last quarter century up to 2050 should be regarded as purely illustrative since the precision of even demographic forecasts at that horizon is near non-existent. The upturn reflects an assumption of progressive ageing that may well be stifled by rising fertility, rising mortality or immigration from developing countries.

The computations do not constitute forecasts of the average current account balance, since we have not taken into consideration the development of other variables nor the dynamic impact of the changing age distribution. Figure 4 oonly shows the magnitude of the direct age impact on the current account given that the estimated relation does not change. Although more modest than the impacts of 5-6 percentage points of GDP on the world scale predicted by Higgins' estimates[16] the spread is still around 2 percentage points of GDP in the OECD. In absolute numbers this is more than comparable with Higgins' effects since income is so much higher in the OECD countris. Anyway, the effects are clearly large enough to merit attention from policy makers and forecasters.

Thus, we would expect that the average OECD country for the moment is experiencing a current account surplus or at least diminishing deficits. This will go on up to around 2010 when the trend reverses due to the large postwar

[16]In Higgins (1998) Table 7 predicts a positive age effect on the current account both in OECD and the rest of the world up to 2010 of around 3.2 percentage points.

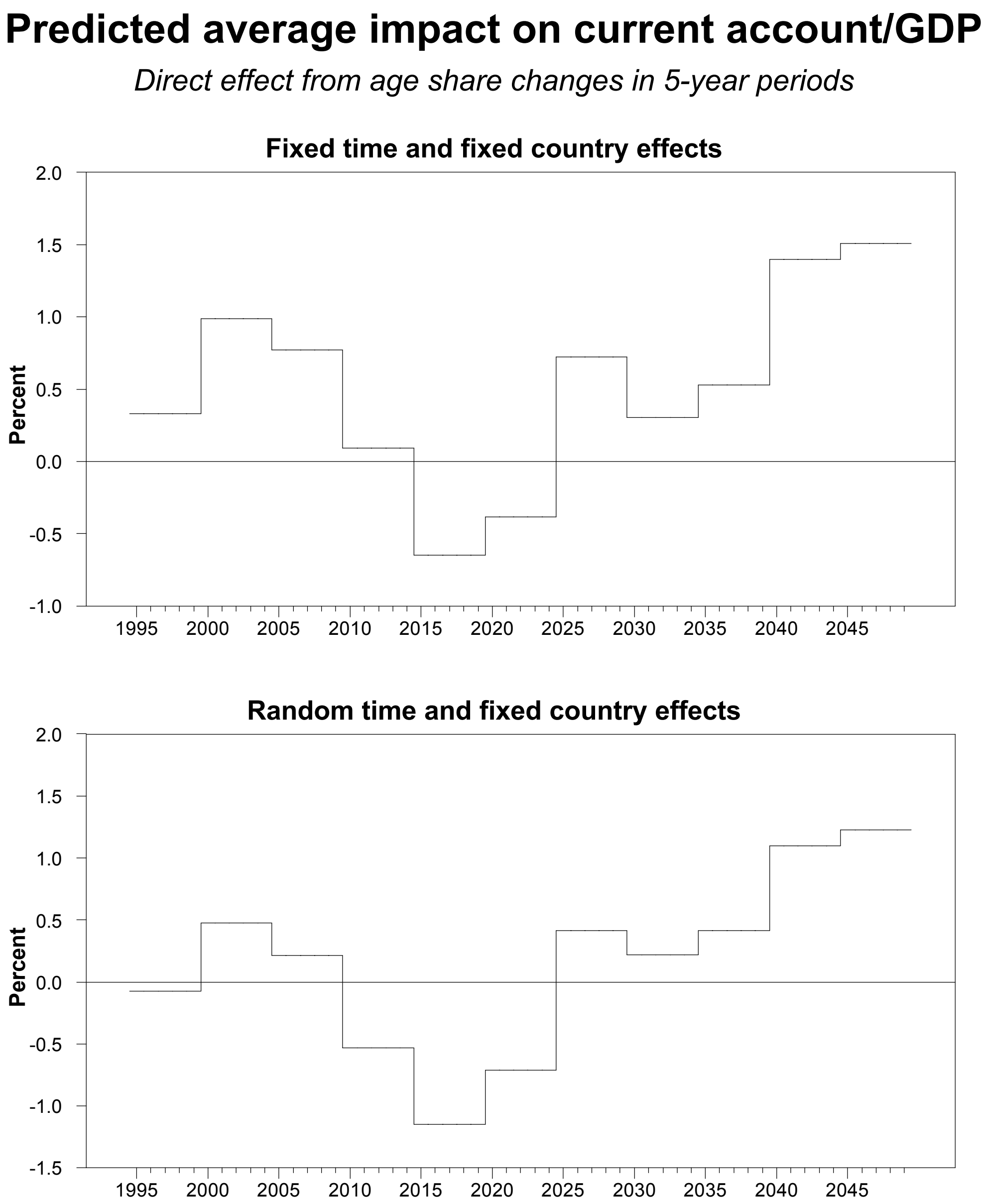

Figure 4: Impact on OECD countries current account balances 1995-2050 according to 5-year estimates using UN population forecasts. Effects have been averaged over countries and the dynamic effects through lags are not accounted for.

cohorts starting to retire. The downward trend continues up to between 2020 and 2025 where the "age cycle" turns again. However, it should be stressed that age structure in a regression sense explains only a minor part of the current account fluctuations. Business cycle variation around this trend may make the outcome in any given year deviate considerably from the age trend. Exchange rate and trade policies will also influence these deviations from the underlying pressure.

4.1 Some interesting points for future research

There is an empirically established home-country bias: saving and investment tends to be tighter correlated than would be expected in view of the capital mobility on international capital markets. This phenomenon has been the focus of much debate since the seminal Feldstein and Horioka (1980) article. This so called Feldstein-Horioka puzzle has generated many both empirical and theoretical papers since it was interpreted to imply a lack of capital mobility that was at odds with the integration of international capital markets. In an early assessment of the evidence Frankel et al. (1986) pointed out that the correlation seemed to be higher in industrialized countries and higher after 1973 than before.

Our results may give a contribution to an explanation of this empirical fact, although it has little to say on the question of whether the correlation reflects capital mobility. Since the age effect patterns of saving and investment are pretty close, even if not wholly overlapping, variations in saving and investment in a country would tend to correlate even if capital markets were completely free. The underlying variation in age structure would tend to coordinate movements in investment and saving independently of each other. Juxtaposing our results with Higgins a reasonable guess is that this should hold to a higher extent for developed countries.

Coakley et al. (1996) find in an OECD panel that saving and investment cointegrate and that this explains the Feldstein-Horioka correlation between saving and investment. Although they give another explanation for this cointegration in terms of a solvency constraint, it would be interesting to explore age structure coordination as an alternative explanation for the cointegrating vector.

Another interesting fact is that Lindh and Malmberg (1998) finds that inflation is correlated to age structure changes with a pattern that is exactly the opposite of the one we find for the current account. The same basic economic forces that transmit the age effect to the current account via differences in effects on saving and investment could would also cause aggregate demand effects that would increase absorption and drive differential changes in the price level. If purchasing power parity holds, this would then need to be reflected in real exchange rates.

If this can be empirically verified it is something that will have implications for the choice of exchange rate regimes and currency areas. Different movements in the age structure of countries would be reflected in adjustments of their exchange rates. This is another interesting topic for future research.

5 Summary and conclusions

We have here explored the empirical relation between saving and investment on the one hand and the age distribution of the population on the other hand in a sample of OECD countries. Our results confirm previous studies on other data samples in that we find a statistically significant relation, which explains a considerable fraction of the long-term variation when due consideration is given to the persistence and cumulative nature of the effects. But we find that in the OECD there is much less difference between the peaks of the age patterns of investment and saving, respectively.

The reason for this different result is the much older population in the OECD countries as compared to the world sample used by Higgins (1998) and the East Asian sample used by Higgins and Williamson (1997). Disaggregating investment we find that increases in the middle-aged population mainly stimulates private business investment while increases in the young working population mainly increases housing investment. Since household formation and the acquisition of own housing is concentrated at the ages of young adults the latter effect is not unexpected. There are also good reasons to believe that a younger population is more mobile and migrates much more readily into growing urban areas.

The positive effect of the middle-aged population on business investment might seem more puzzling, but at least two reasonable—complementary rather than competing hypotheses—could be put forward. If labor efficiency increases through learning-by-doing an ageing working population will decrease the ratio of capital to effective labor. This stimulates investment if factor prices remain constant. The supply of experienced labor will actually increase so their relative wages would tend to decrease but labor market rigidities would lead us to believe that this counteracting effect is of little importance.

It is an established fact that people generally shift their portfolio from real assets, predominantly real estate, towards more liquid financial assets as they get closer to retirement. This would increase the part of total wealth available for investment and thus stimulate investment by decreasing financial costs. This would also tend to eliminate the counteracting effect of possibly decreasing wages on the productivity mechanism and might even strengthen it.

Further research on these issues is, of course, needed. Such research would also serve to clarify whether the strong focus on consumption smoothing and household decisions in explaining aggregate saving might have been misdirected. Clarification of the impact of age structure on these variables will also contribute to long-term forecasting since age structure is one of the very few explanatory variables which we can project for several years ahead and still be rather confident that the uncertainty is manageably small.

The results here also give rise to two other interesting conjectures. First, that some part of the home-country bias puzzle can be explained by age structure coordination of the demand for investment and the supply of saving. Second, that trend movements in real exchange rates may be driven by differences in the age structure of countries.

References

Almon, S.: 1965, The distributed lag between capital appropriations and expenditures, *Econometrica* **33**(1), 178–196.

Andersson, B.: 1998, Scandinavian evidence on growth and age structure, *Working Paper 1998:4*, Department of Economics, Uppsala University, Uppsala.

Bloom, D. E. and Sachs, J. D.: 1998, Geography, demography, and economic growth in Africa, *Brookings Papers on Economic Activity* (1998:2), 207–273.

Bloom, D. E. and Williamson, J. G.: 1998, Demographic transitions and economic miracles in emerging Asia, *World Bank Economic Review* **12**(3), 419–455.

Bosworth, B., Burtless, G. and Sabelhaus, J.: 1991, Fertility waves, aggregate savings and the rate of interest, *Brookings Papers on Economic Activity* **1:1991**, 183–256.

Bosworth, B. J.: 1993, *Saving and Investment in a Global Economy*, The Brookings Institution, , Washington D.C.

Coakley, J., Kulasi, F. and Smith, R.: 1996, Current account solvency and the Feldstein-Horioka puzzle, *Economic Journal* **106**(436), 620–627.

Fair, R. C. and Dominguez, K.: 1991, Effects of the changing U.S. age distribution on macro-economic equations, *American Economic Review* **81**, 1276–1294.

Feldstein, M. S. and Horioka, C. Y.: 1980, Domestic saving and international capital flows, *Economic Journal* **90**(358), 314–329.

Frankel, J. G., Dooley, M. P. and Mathieson, D. J.: 1986, International capital mobility in developing countries vs industrial countries: What do saving-investment correlations tell, *Working Paper 2043*, National Bureau of Economic Research, Cambridge, Massachusetts.

Fry, M. J. and Mason, A.: 1982, The variable rate-of-growth effect in the life-cycle saving model, *Economic Inquiry* **20**, 426–442.

Herbertsson, T. T. and Zoega, G.: 1999, Trade surpluses and life-cycle saving behaviour, *Economics Letters* . Forthcoming.

Higgins, M.: 1998, Demography, national savings, and international capital flows, *International Economic Review* **39**(2), 343–369.

Higgins, M. and Williamson, J. G.: 1997, Asian demography and foreign capital dependence, *Population and Development Review* **23**(2), 261–293.

Horioka, C. Y.: 1991, The determinants of Japan's saving rate: The impact of the age structure of the population and other factors, *The Economic Studies Quarterly* **42**(3), 237–253.

Huber, P.: 1973, Robust regression: Asymptotics, conjectures and Monte Carlo, *Annals of Statistics* **1**, 55–82.

Kelley, A. C. and Schmidt, R. M.: 1996, Saving, dependency and development, *Journal of Population Economics* **9**(4), 365–386.

Kiviet, J. F.: 1995, On bias, inconsistency, and efficiency of various estimators in dynamic panel data models, *Journal of Econometrics* **68**, 53–78.

Leff, N. H.: 1969, Dependency rates and saving rates, *American Economic Review* **59**, 886–896.

Lenehan, A.: 1996, The macroeconomic effects of the postwar baby boom: Evidence from Australia, *Journal of Macroeconomics* **18**, 155–169.

Lindh, T.: 1999, Age structure and economic policy—the case of saving and growth, *Population Research and Policy Review* **18**(3), 261–277.

Lindh, T. and Malmberg, B.: 1998, Age structure and inflation—a Wicksellian interpretation of the OECD data, *Journal of Economic Behavior and Organization* **36**(1), 17–35.

Lindh, T. and Malmberg, B.: 1999, Age structure effects and growth in the OECD, 1950–90, *Journal of Population Economics* **12**(3), 431–449.

Malmberg, B.: 1994, Age structure effects on economic growth: Swedish evidence, *Scandinavian Economic History Review* **42**(3), 279–95.

Mankiw, N. G. and Weil, D. N.: 1989, The baby boom, the baby bust, and the housing market, *Regional Science and Urban Economics* **19**, 235–258.

Mason, A.: 1987, National saving rates and population growth: A new model and new evidence, *in* D. G. Johnson and R. D. Lee (eds), *Population Growth and Economic Development: Issues and Evidence*, The University of Wisconsin Press, Madison, Wisconsin, Chapter 13.

McMillan, H. M. and Baesel, J. B.: 1990, The macroeconomic impact of the baby boom generation, *Journal of Macroeconomics* **12**(2), 167–195.

Meen, G.: 1998, Modelling sustainable home-ownership: Demographics or economics?, *Urban Studies* **35**(11), 1919–1934.

Miles, D.: 1999, Modelling the impact of demographic change upon the economy, *Economic Journal* **109**(452), 1–36.

Modigliani, F.: 1975, The life cycle hypothesis of saving twenty years later, *in* M. Parkin and A. R. Nobay (eds), *Contemporary Issues in Economics*, Manchester University Press, Manchester.

Nerlove, M.: 1971, Further evidence on the estimation of dynamic economic relations from a time series of cross sections, *Econometrica* **39**(2), 359–382.

Newey, W. K. and West, K. D.: 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* **55**(3), 703–708.

Nickell, S.: 1981, Biases in dynamic models with fixed effects, *Econometrica* **49**(6), 1417–1426.

OECD: 1997, *Statistical Compendium*, Vol. 97:1, OECD Publications, Paris.

Persson, J.: 1998, Demographics, human capital, convergence and growth— an analysis of the US states 1920-1990, *Essays on Economic Growth*, Institute of International Economic Studies, Stockholm University, Stockholm. Doctoral thesis.

Pesaran, H., Smith, R. and Im, K. S.: 1996, Dynamic linear models for heterogenous panels, *in* L. Mátyás and P. Sevestre (eds), *The Econometrics of Panel Data: A Handbook of the Theory with Applications. Second Revised Edition*, Kluwer Academic Publishers, Dordrecht, chapter 8.

Poterba, J. M.: 1994, *Public Policies and Household Saving*, number 6774, University of Chicago Press for NBER, Cambridge, Massachusetts.

Skinner, J.: 1989, Housing wealth and aggregate saving, *Regional Science and Urban Economics* **19**, 305–324.

Swamy, P.: 1970, Efficient inference in a random coefficient regression model, *Econometrica* **38**, 311–323.

Taylor, A. M. and Williamson, J. G.: 1994, Capital flows to the New World as an intergenerational transfer, *Journal of Political Economy* **102**(2), 348–371.

United Nations: 1990, *Global Estimates and Projections of Population by Sex and Age: The 1994 Revision*, New York.

Weil, D. N.: 1994, The saving of the elderly in micro and macro data, *Quarterly Journal of Economics* **109**(1), 55–81.

Appendix

A Polynomial restrictions on age coefficients

Estimation of age effects under a polynomial restriction is similar to an Almon (1965) lag specification. We ignore other explanatory variables here and assume that the population age shares, s_{kt}, for the cohort k years old at time t, are the only explanatory variables in a linear regression model for some dependent variable, y_t, with a residual error of u_t.

$$y_t = \alpha_0 + \sum_{k=1}^{n} \alpha_k s_{kt} + u_t$$

Imposing the assumption that the age share coefficients $a_k = p(k)$ for some polynomial p taking age (or mean age) of the group as argument we can construct a set of new explanatory variables by aggregation of the age groups. Since it is impossible to identify the intercept separately from the coefficients of a linear combination of age group shares we also impose the further assumption that the α_k sum to zero. This implies that a uniform age distribution will have no net effect on y_t. In principle the polynomial could be of any degree and thus be fitted to any pattern of age coefficients. In practice only second or third degree polynomials are used. We use a third degree polynomial like Higgins (1998):

$$a_k = \gamma_0 + \gamma_1 k + \gamma_2 k^2 + \gamma_3 k^3$$

Thus we can write down the sum of age share effects as

$$\begin{aligned} \sum_{k=1}^{n} \alpha_k s_{kt} &= \sum_{k=1}^{n} \left(\gamma_0 + \gamma_1 k + \gamma_2 k^2 + \gamma_3 k^3\right) s_{kt} \\ &= \gamma_0 + \sum_{k=1}^{n} \left(\gamma_1 k + \gamma_2 k^2 + \gamma_3 k^3\right) s_{kt} \end{aligned}$$

The zero sum restriction is used to get rid of the constant by elimination.

$$\sum_{k=1}^{n} \alpha_k = 0 \;\Rightarrow\; n\gamma_0 = -\gamma_1 \sum_{k=1}^{n} k - \gamma_2 \sum_{k=1}^{n} k^2 - \gamma_3 \sum_{k=1}^{n} k^3$$

and we get the following specification to estimate

$$y_t = \alpha_0 + \gamma_1 \underbrace{\sum_{k=1}^{n} k \left(s_{kt} - \frac{1}{n}\right)}_{D_1} + \gamma_2 \underbrace{\sum_{k=1}^{n} k^2 \left(s_{kt} - \frac{1}{n}\right)}_{D_2} + \gamma_3 \underbrace{\sum_{k=1}^{n} k^3 \left(s_{kt} - \frac{1}{n}\right)}_{D_3} + u_t$$

A large number of age parameters to estimate can thus be replaced with a more parsimonious set of polynomial coefficients. The constant γ_0 can be recovered under the zero sum restriction.

B 5-year time aggregation

In this appendix we show formally how time aggregation will affect estimation results when we use 5-year data given that the true model is an annual autoregressive specification. To keep it simple we only consider how some dependent variable y_t relates to one explanatory variable x_t and an error term u_t.with no constant. Thus the "true" annual model is

$$y_t = \alpha y_{t-1} + \beta x_t + u_t$$

By recursive substitution it is easy to see that

$$y_t = \alpha^5 y_{t-5} + \beta \sum_{i=0}^{4} \alpha^i x_{t-i} + \sum_{i=0}^{4} \alpha^i u_{t-i}$$

Thus the 5-year average of the dependent variable can be written

$$\bar{y}_t = \frac{1}{5} \sum_{i=0}^{4} y_{t-i} = \alpha^5 \bar{y}_{t-5} + \beta \sum_{i=0}^{4} \alpha^i \bar{x}_{t-i} + \sum_{i=0}^{4} \alpha^i \bar{u}_{t-i}$$

From this expression we can deduce

1. If $\alpha < 1$ the autoregressive coefficient will diminish with five-year data. In fact, if $\alpha = 0.8$ then $\alpha^5 = 0.32768$.

2. Our residuals in the 5-year estimations will be serially correlated even if they were not so before.

3. The coefficient of an explanatory variable $\bar{x}_{t-i}$ would diminish in the same way as the lag coefficient provided we used all the appropriate lags of the averages in the 5-year regression and not encountered problems with the collinearity between the averages.

4. In practice we use $\bar{x}_t$ which is correlated with previous averages and possibly with the errors, too. Taking an extreme case and assuming that $\bar{x}_{t-i} = \bar{x}_t$ over the period, the coefficient on the contrary increases with

$$\sum_{i=0}^{4} \alpha^i = \left. \frac{1-\alpha^5}{1-\alpha} \right|_{\alpha=0.8} = 3.3616$$

5. If the explanatory variable is simultaneously determined with the dependent variable, or more importantly, only predetermined the year before we will get endogeneity bias in the estimated coefficient when we use 5-year data because the average will be correlated with the error, even if that was not the case using annual data.

The first point provides a yard-stick that allows us to say that the coefficients on the savings lag in Table 1 are reasonable while the lag coefficient in Table 3 diminishes too much when we change to 5-year data. Point 2 is by itself no serious problems since the parameter estimates will remain consistent and the standard errors have been corrected for serial correlation. However, in conjunction with point 5 it makes it pointless to use lags as instruments to try to solve endogeneity problems. Point 3 would be relevant only if the explanatory variables were stochastically independent, which is clearly not the case. Point 4 implies that for strongly persistent variables like the age variables a magnification of the coefficient with a factor around 3 is quite reasonable.

Point number 5 is obviously of concern with respect to growth and the relative price of investment in our applications in the text. But it is not innocent with regard to the age variables either. Although they react rather slowly to economic changes, the determinants of the age distribution do change. Fertility, migration and mortality will be affected by current economic conditions and with a 5-year lag those effects may be considerable. It is therefore prudent to use initial age structure in the period instead of the average to avoid the endogeneity bias.

This expedient would not be expected to work well with economic variables with high levels of high frequency noise like growth. The correlation between the smoothed dependent variable and the initial value of growth would then be too low for estimation. But it would be expected to work rather well with slow-moving age variables, where the high-frequency part in the dependent variable should not be expected to correlate with the age variables anyway.

However, it does introduce another problem. Using s_{t-5} instead of $\bar{s}_t$ as explanatory variable will lead to an addition to the residual of the form

$$\beta \sum_{i=0}^{4} \alpha^i (\bar{s}_t - s_{t-5})$$

Age group shares per se are both highly serially correlated and rather highly correlated between OECD countries so this term is likely to show up either in a country-specific intercept or in a time-specific intercept in the 5-year estimates. A conjecture—which we have not verified—is that a random effects specification, therefore could be more appropriate in the 5-year estimations since it will not attribute all of the mean of the residuals to specific intercepts.