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Scandinavian Evidence on Growth and Age Structure*

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Abstract

The age distribution is seldom taken into consideration in macroeconomic, and macro-econometric papers. This in spite of the fact that established economic theories predict that demographic factors will affect the aggregate economy. This paper focuses on economic growth and investigates empirically the influence of age variables on growth. Unlike other recent papers on the subject, the focus here is on annual data and individual countries, namely Denmark, Finland, Norway, and Sweden. Estimations of a typical growth specification, augmented with age variables and other, more volatile, economic variables, are carried out, and results from these regressions seem to indicate that economic growth is indeed affected by the age distribution. The effect does not disappear when the specification is reestimated using an instrumental variable estimator in order to correct for the potential endogeneity of the economic variables. Since the age variables are highly correlated with each other, experiments with ridge regressions are also made in order to mitigate the collinearity which obscures the results when all of the age variables are included in the regressions.

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1. Introduction

Can fluctuations in a country's age structure help explain economic growth? Indeed, does the age distribution have any relevance in macroeconomic studies? In macro-empirical papers demographic factors are seldom taken into consideration in spite of the fact that several established economic theories, e g the life-cycle theory of savings and the human capital theory, predict that the demographic situation will affect the aggregate economy.

According to the life-cycle theory of savings (e g Modigliani & Brumberg 1954, 1979) there is a connection between specific cohort behaviour and aggregate savings and consumption. The Bentzel effect (Bentzel 1959; Modigliani 1986), for example, predicts that there will be a positive correlation between growth and savings due to higher lifetime resources, and therefore savings, of younger cohorts relative to the dissaving of retired cohorts. More complicated versions of the life-cycle model, where life-cycle earnings and family needs are added, naturally can make the age structure of the population even more influential, although the sign of the correlation with growth will be less determinate.

The human capital theory (e g Becker 1962; Mincer 1962) has been the dominant theory in the wage-determination literature. Recognizing the fact that learning by doing is an important source of human-capital formation, a typical result of this theory will be that a worker increases the hours worked early in life in order to rapidly accumulate human capital. A worker's stock of human capital will then peak in the middle ages, towards the end of the working years. A nation's stock of human capital should then, ceteris paribus, benefit from a labour force with a large number of experienced workers.

As for empirical evidence of age-distribution effects, there are some studies focusing mainly on savings, for example Mason (1987) and Horioka (1989, 1991). Berg (1989, 1996) finds a correlation between varying cohort sizes and savings and the composition of aggregate savings. Blomquist and Wijkander (1994) simulate an overlapping generations model with demographic changes of a baby boom type and find patterns which resemble actual macroeconomic patterns.

McMillan and Baesel (1990) also consider the impact of the baby boom generation. Using postwar data for the USA, they find that measures of the age composition of the population influenced a number of macroeconomic variables, including the real interest rate, unemployment, and output growth. The effects of the changing US age distribution on various macroeconomic relationships are also examined by Fair and Dominguez (1991). They find that age-distribution variables have significant explanatory power in consumption, housing-investment, money demand, and labour-force participation equations.

Studies of the impact of the age distribution on economic growth include McMillan and Baesel, as mentioned above, Brander and Dowrick (1994), Malmberg (1994), Lindh and Malmberg (1995, 1996), and Lenehan (1996). Following Mankiw, Romer and Weil (1992), Lindh and Malmberg incorporate the age structure in a human-capital augmented Solow growth model, and study what impact this has on the economic growth rate in the OECD countries. Their estimations show a strong positive effect of the upper middle-aged group, defined as the group 50-64, while the group over 65 years has a negative effect.

This study will also focus on the relationship between the age distribution and economic growth. However, unlike the paper by Lindh and Malmberg who estimate their model in a panel setting using 5-year averages, the focus in this paper will be on individual countries and annual data. One of the reasons for doing this is the age distribution's potentiality as a forecasting variable; should there exist a stable relationship between a country's economic performance and age structure medium-run forecasting would be greatly facilitated since fairly accurate demographic projections are easily obtained.

Focusing on individual countries and yearly growth rates makes it harder to detect any demographic impact on growth since all of the short-run dynamics of business cycles will be present in the data; the age series vary at low frequencies and should, perhaps, have greater impact on the aggregate economy in a longer perspective. However, if age-structure effects operate through life-cycle savings and/or the aggregate human capital, the effects should be discernible even in a shorter perspective; not because business cycles in fact are driven primarily by changes in the age distribution, but because the impact and propagation of shocks ought to be moderated by the state of the age distribution.

Capturing the entire dynamics of business cycles is a formidable task and not one which will be pursued here. The objective of this paper is not to develop a fully exhaustive macroeconomic model, but merely to investigate the potential influence of a country's age distribution on the aggregate economic activity. Hence, the form of the paper will be explorative rather than formal, the empirical specifications motivated rather than derived. In this respect, the study will be more in line with the papers by McMillan and Baesel, Lenehan, and Malmberg. Keeping the analysis as transparent as possible is also the reason for limiting the empirical specifications to the single-regression level.

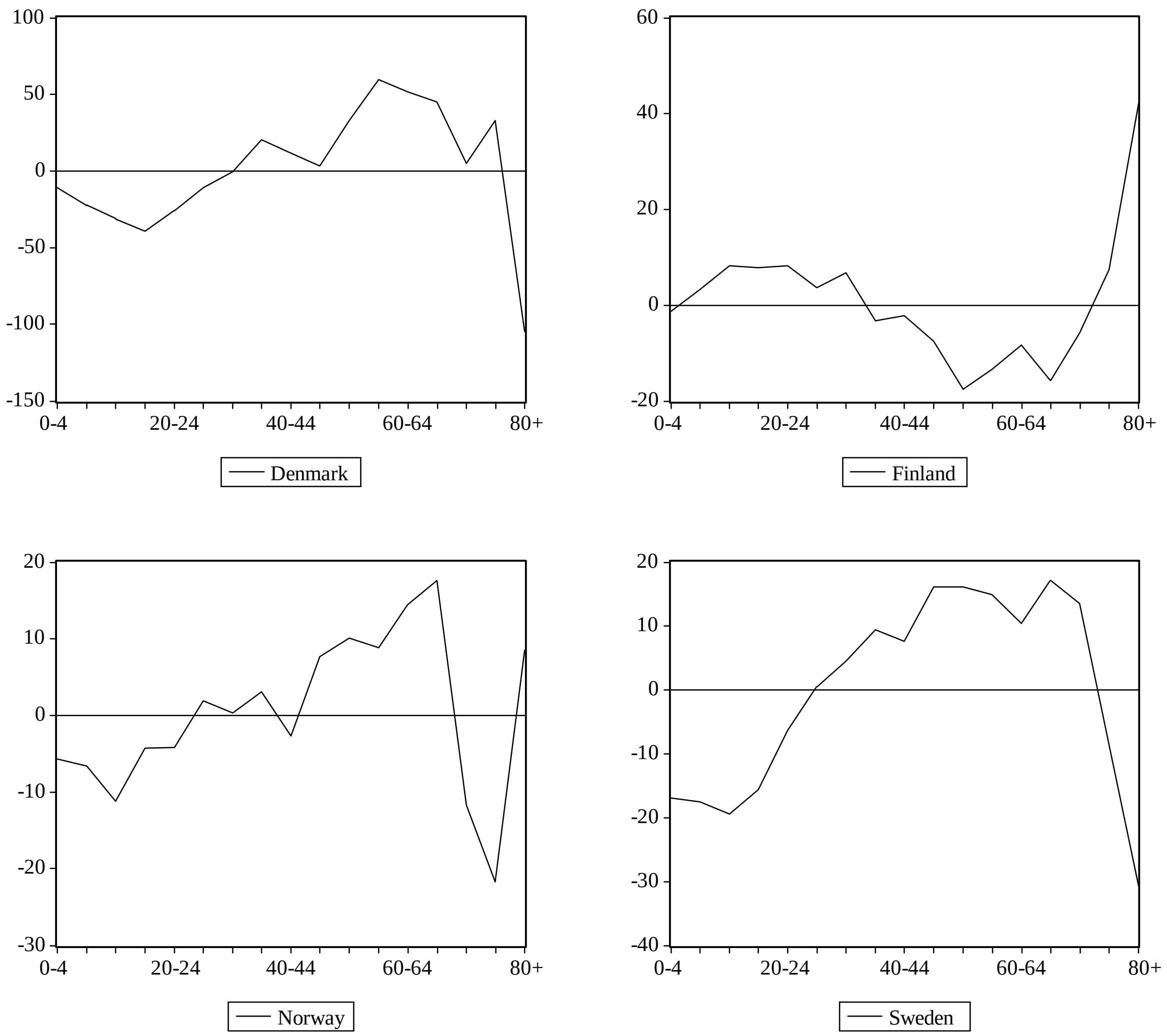
The results of the empirical investigation in this paper confirm the findings in the papers mentioned above that the age distribution is a significant variable in the determination of growth, and that this effect is discernible also when we consider shorter time-spans. Using annual data for Denmark, Finland, Norway, and Sweden, the joint significance of four age variables, representing the age distribution, can not be rejected in a typical growth specification which is augmented with cyclical economic variables. Correcting the potential bias in these estimates from the simultaneous determination of the economic variables does not change this result. Determining a specific pattern of the age-share impact can be done to some extent for each separate country, but a common pattern for all of the countries is not crystallized.

The remainder of this paper starts with a brief, preliminary investigation of different age shares' partial influence on growth in section 2. Section 3 begins with definitions and a data description. Estimations of a general growth specification including age shares are carried out in section 3.2. The following two subsections deal with potential problems which might obscure the estimation results in 3.2. Section 3.3 reestimates the general specification using an instrumental-variable estimator in order to avoid simultaneity bias. In section 3.4 the focus is on the high degree of correlation of the age variables and experiments with ridge regressions are carried out in order to mitigate this problem. The results are summarized in section 4.

2. Age share impacts

As a first exploration, figure 2.1 graphs the simple least-squares regression coefficients from a regression with the growth rate of GDP per capita as dependent variable, and age shares in 5-year intervals as regressors. These regressions only serve as a preliminary investigation, revealing nothing more than the partial impacts of the different age shares when the effect of other age shares on growth has been netted out.

Figure 2.1 Plots of the regression coefficients of the different age shares.



Data sources: see appendix A.2. Sample period 1950-1992.

Except for the Finnish case, the pattern of the age shares' impact on growth is similar across the countries.[1] The youngest and oldest age shares have a negative influence whereas the prime and middle aged, i e people in their thirties and forties, and in their fifties and sixties respectively, exercise a positive influence. Among the middle aged, the largest impact comes from people who are about to end, or have just ended, their working career.

These partial impacts on growth differ from the pure correlations between the different age shares and growth displayed in appendix A.1. The correlation pattern, which basically is the same for all countries, except for Finland where the pattern is the same but the magnitudes smaller, show positive correlations with growth for the youngest age shares, negative for the prime aged, positive correlations again for the middle aged, and negative yet again for the retired. This suggests caution when interpreting the impact of single age variables in regressions which lack a measure of the entire age distribution. It also points to the possibility that arbitrary aggregation of age shares might result in the addition of subgroups with opposite impacts, leaving an aggregate variable with little explanatory value.

Returning to figure 2.1 the results are well in line with the human-capital view described in the introduction. A possible explanation for negative coefficients of the young and old age shares might be that education and health care reallocate human capital from production that by the national account's definition is more productive. However, if higher savings generate higher growth, the results might also be in line with the life-cycle theory of savings, where the life-cycle savings are "hump-shaped", i e the young and old borrow and dissave while the middle-aged save. It remains to be investigated whether any significant influence from age variables on growth can be found when other economic variables are added, and, if so, whether the influence from the age variables will have the same pattern as in this primary investigation.

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[1] In spite of the high degree of collinearity, the age share coefficients are generally well determined in the Danish and Swedish regressions; they are less so in the Norwegian regression, and not at all in the Finnish one.

3. Growth estimations

In an influential article Mankiw, Romer, and Weil (1992) showed that aggregate output growth can be well explained by a traditional neoclassical growth model, where both physical and human capital is included. Using this model as a point of departure Lindh and Malmberg (1995, 1996) included the age distribution as a moderating effect on the human capital utilization. The regressions below are influenced by these specifications. The growth rate of GDP per capita is explained by the growth rate of the investment share, the growth rate of the population, and age variables. This is virtually the same specification as in Lindh and Malmberg but it also bears a close resemblance to the specification in Mankiw, Romer and Weil, and the base regression in the sensitivity analysis by Levine and Renelt (1992).

Surely this baseline specification is too simple to explain all of the volatility of the yearly data. Therefore it is augmented with variables which should catch some of the business cycle variation, namely the growth rate of the net foreign balance, the growth rate of public consumption expenditure, and the rate of inflation, some of which have been found significant in growth regressions in other papers.[2] This addition of variables is by no means exhaustive. But these three variables have the advantage of being readily available and will hopefully explain different characteristics of the cyclicity in the data.

The choice to include the growth rate of the investment share instead of the level, which is the standard case in growth studies, merits some explanation. Experiments with the dynamic specification where both the contemporaneous and lagged investment shares are included point very firmly toward a specification with the growth rate of the investment share; the coefficients for the contemporaneous and lagged investment variables are equal but with opposite signs. This result seems very robust, both across countries and specifications.

[2] See e g Levine and Renelt (1992) for a summary.

There are a number of reasons why the growth rate of the investment share works better here. The investment decisions might for example be determined by an accelerator type of model where current investments are a function of lagged investments and the growth rate of income. There is also the possibility that there is information about the long-run co-movements of the GDP level and total investments which is neglected in the specification used here.[3] However, the disentanglement of the true output/investment dynamics goes beyond the purpose of this paper. In order to keep the focus on the demographic variables the regressions will not leave the single-equation level, so the potential endogeneity of investments in the growth regressions will be corrected by IV methods.

3.1 Data and definitions

Data on the economic variables were taken from Penn World Table 5.6 (Summers & Heston 1991) for the period 1950 to 1992.[4] In the regressions the dependent variable, Δy, is the yearly growth rate of real GDP per capita and Δi is the growth rate of the investment share. The variable x is the growth rate of the total population modified by the addition of a stylized value of 0.05 which can be thought of as a summary capital depreciation factor that includes exogenous technological change.[5] All of the regressors, including the age shares, are in logarithms. Apart from being the common outcome of approximations of transitional dynamics, this also has the advantage of alleviating a potential heteroskedasticity problem. The growth rates of the net foreign balance and the public consumption expenditures, and the inflation rate are labeled Δnfb, Δg, and π respectively.

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[3] More specifically, since tests show that both the level of GDP and total investments are I(1)-variables they might be co-integrated, indicating that there might be an error-correction representation of the two variables which will include both long- and short term dynamics. It is possible that it is parts of the short-term dynamics of such a representation that is caught in the regressions presented here.
[4] See appendix A.2 for a more detailed description of the data.
[5] See e g Mankiw, Romer and Weil (1992).

Data on the population divided into age shares, n_i, were taken from the official statistics of each country. Since n_i is assumed to be the logarithm of the initial age share of a year, data that refer to the last of December one year have been used as data regarding the first of January the following year. In order to get a measure of the age distribution with a moderate number of age shares, that still captures the specific influence on growth of the different stages in life, the population is divided into five different age groups: youth, young adulthood, prime age, middle age, and retired. These are defined as 0-14, 15-29, 30-49, 50-64, and 65+ years of age.

This classification is motivated from the viewpoint of both human capital and life-cycle savings theories. From a human-capital perspective we should expect to find the impact of these age variables to be hump-shaped, with the peak in the middle-aged group, and possibly with negative impacts from the young and retired. But as was stated in the introduction, this pattern could be supported from a life-cycle savings perspective as well. The classification is also in accordance with the results in section 2.

The degree of integration of the variables are important in time-series regressions. Judging by standard tests, the growth rate of the GDP per capita is an I(0)-variable, so the question here is not whether there is a spurious regression problem but rather if the regressions will be balanced in the sense of Banerjee et al (1993), i e if the regressand and the regressors have the same order of integration. If some of the regressors are I(1) the inference could not be based on asymptotic normality since the distributions of the coefficient estimates would be non-standard. However, should the I(1)-variables be co-integrated standard t-tables could be used for inference regarding individual coefficient estimates, although joint significance tests could only be carried out for the stationary regressors.

Regarding the degree of integration of the variables, all but the age variables seem to be I(0) according to standard tests.[6] However, since the cyclicity in the age-share series is very prolonged, it is almost impossible for tests to reject the hypothesis of a unit root when testing the short time span used here. Indeed, testing for the presence of unit roots in age-share series over longer periods, e g Norwegian series going back to 1848, changes the results and the unit-root hypothesis can be rejected for all but one series. So, in the regressions below, all of the demographic variables will be treated as non-integrated.

A perhaps more serious cause for concern is the high correlation between theregressors in the general specification. The tables in appendix A.3 show the correlation matrices. As can be seen from these tables the regressions are likely to suffer from high degrees ofcollinearity between the regressors. A common feature for all of the countries is the extremely high correlation between the age shares 0-14 and 65+. Therefore, the share 0-14 years is dropped in the regressions below. However, regressions including all of the age shares are reported in section 3.4.

3.2 General regressions

Table 3.1 below reports results from OLS regressions of the model described above. Note that the specification of the dynamics is not obvious. In the estimations below no lagged variables are included. However, experiments with a more general dynamic specification where all variables, except the demographic ones, have a lagged as well as a contemporaneous effect on growth, have also been made and are reported in appendix A.4. The results regarding the age variables, individually and jointly, are very similar to the results reported here.

[6] Available from the author upon request.

Table 3.1 Estimation results, OLS.

	Denmark		Finland		Norway		Sweden	
Variable	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
constant	0.604[b]	0.325	0.045	0.644	1.429	0.946	0.929[a]	0.337
$n_{15\text{-}29}$	0.095	0.100	0.081	0.145	0.278[a]	0.097	0.179[a]	0.070
$n_{30\text{-}49}$	0.181[a]	0.087	0.051	0.216	0.257	0.165	0.296[a]	0.076
$n_{50\text{-}64}$	0.393[a]	0.129	0.110	0.151	0.373[b]	0.195	0.274[a]	0.081
$n_{65\text{-}}$	-0.049	0.042	-0.060	0.071	-0.008	0.063	-0.0002	0.027
x	-0.143	0.092	-0.082	0.052	-0.015	0.132	-0.084	0.052
Δi	0.203[a]	0.030	0.051	0.064	0.003	0.021	0.076[a]	0.030
Δnfb	0.001[b]	0.001	0.001	0.001	-0.001[a]	0.0004	0.001	0.0006
Δg	-0.105	0.092	-0.665[a]	0.120	-0.356[b]	0.191	-0.239[a]	0.082
π	0.020	0.022	0.047[b]	0.027	-0.009	0.035	0.032[b]	0.018
Obs	42		42		42		42	
R^2 *adj.*	0.822		0.843		0.290		0.632	
Chi-2 all	269.248	0.000	393.531	0.000	44.538	0.000	114.407	0.000
Chi-2 age	11.066	0.026	13.252	0.010	24.989	0.000	58.205	0.000
RESET	1.189	0.319	4.325	0.022	4.083	0.027	0.622	0.544
White	5.584	0.998	13.723	0.747	23.065	0.188	23.409	0.175
DW	2.035		1.804		1.540		1.940	
B-G LM	3.925	0.141	0.548	0.760	5.291	0.071	3.920	0.141
Q-stat. 1	0.039	0.844	0.028	0.867	1.705	0.192	0.307	0.579
2	2.939	0.230	0.390	0.823	3.691	0.158	2.760	0.252
3	2.942	0.401	0.911	0.823	5.994	0.112	4.793	0.188
4	2.956	0.565	1.096	0.895	6.120	0.190	6.033	0.197

Notes: The covariance matrix is estimated with the Newey-West HAC estimator. Standard errors in parenthesis except for the test statistics which have the p-values, i e the marginal significance levels, in parenthesis. Superindex [a] shows that the estimate is significant on the 5%-level, [b] on the 10%-level. R^2 *adj is the* R^2 *adjusted for the number of variables in the regression. DW is the Durbin-Watson statistic for a test of first order serial correlation. The hypothesis that all of the coefficients, but the constant, are zero is tested with the Wald test Chi-2 all. Chi-2 age is a joint test of the insignificance of the age coefficients. RESET and White is the Ramsey misspecification, and White heteroskedasticity tests respectively. Tests for higher order serial correlation are carried out with B-G LM, which is a Breusch-Godfrey test for second order serial correlation, and Q-stat n which is the Box-Ljung q-statistic of serial correlation upto the n:th order. Estimations made in EViews 2.0.*

In all, the fit is encouraging, except for the Norwegian regression. In the Danish and particularly the Swedish estimations the majority of the coefficients are well determined. The lack of individually significant coefficients in the Finnish case, in spite of the good fit, is most likely due to multicollinearity. Focusing on the age parameters they are jointly significant in all regressions and their signs are as expected; the effect from the young adults and prime aged is positive for all of the countries, and, although not significant, the coefficient for the retired is negative in all regressions. Note however that, since the youngest age group is excluded, only relative effects of the included age shares are identified; an estimate of the pattern of the entire age distribution can not be inferred.

Test of the residuals do not indicate any major problems in the Danish and Swedish regressions. However, the fact that the RESET-test for functional form is significant for Finland is a cause for reflection since it indicates that the linear introduction of the demographic variables might not be the best way. Interestingly, the test is not significant when the youngest age share is included in the estimation.[7] In fact, when all of the age variables are included in the Finnish regression they are all individually significant, although the coefficient estimates are inflated because of the collinearity problem described further in section 3.4 below.

Extending the regressions with period dummies for the oil crises and the turbulent years at the beginning of the 90s do not change the joint significance of the age shares.[8] In fact, for Denmark and Sweden the results change very little with the period dummies included. In the Norwegian regression the inclusion of the dummies improves the overall fit a great deal, which supports the notion that the original specification is not suited for explaining the Norwegian growth pattern.[9] An alternative specification would have to account for the special effects that oil prices have on the Norwegian economy. Adding period dummies to the Finnish regression gives additional indications of multicollinearity, since this has the effect of reversing the signs of all of the age-share coefficients while not affecting the other parameters much.

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[7] More on these estimations in section 3.4.

[8] Results from these estimations are displayed in appendix A.5. The regressions are augmented with an oil dummy for the period 1974-75 for Denmark, 1976-77 for Finland and Sweden, 1972-79 for Norway, and a ”90s” dummy for the period 1990-92 for Finland, 1991-92 for Sweden, and 1987-89 for Norway.

[9] However, all but one of the age-share coefficients are individually significant, using a 5% critical value, when the dummies are present.

3.3 IV estimations

Apart from the Finnish RESET test of functional form, the diagnostic tests in table 3.1 find no major sign of misspecification, the Norwegian case excepted. For theoretical reasons we would however suspect that the estimates might be biased due to simultaneity issues. Since we are concerned with aggregate economic activity many of the variables are determined simultaneously, and there is reason to believe that the growth rate of GDP plays a part in the determination of many, if not all of the economic variables.[10] For example, the common assumption in growth studies that investments determine growth has been questioned by Blomström, Lipsey and Zejan (1996) who find evidence of reversed causality.

If some of the contemporaneous regressors in fact are determined by GDP growth, the error term in the estimations in table 3.1 will be correlated with these regressors and the OLS estimates of the parameters in table 3.1 will be biased and inconsistent. Moreover, since the estimate of the standard error of the regression will be biased downward, the estimate of the fit of the model will be exaggerated. To accommodate the possible simultaneity bias, the specification above is reestimated using two-stage least squares with the contemporaneous economic variables instrumented. The population growth and age-share variables are taken to be exogenous. Although there certainly is a feed-back effect from economic growth to the age structure, this effect is mostly propagated through the age distribution with a considerable lag and is less likely to pose a problem in the regressions.

[10] However, so called Hausman-tests of the economic variables, which can be interpreted as tests of their exogeneity, are not significant for any of the countries, meaning that the hypothesis that these variables are exogenous can not be rejected.

Table 3.2 Estimation results, 2SLS.

	Denmark		*Finland*		*Sweden*	
Variable	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
constant	0.691	0.494	0.642	0.706	0.702[b]	0.404
$n_{15\text{-}29}$	0.018	0.103	0.202	0.130	0.272[a]	0.094
$n_{30\text{-}49}$	0.114	0.171	0.220	0.225	0.326[a]	0.141
$n_{50\text{-}64}$	0.374[b]	0.201	0.166	0.165	0.214[b]	0.117
$n_{65\text{-}}$	-0.005	0.053	-0.097	0.079	-0.034	0.032
x	-0.062	0.127	-0.021	0.075	-0.167[a]	0.078
Δi	0.168[a]	0.078	0.115	0.240	0.124[a]	0.038
Δnfb	0.001	0.003	0.00001	0.009	-0.0004	0.002
Δg	-0.281	0.410	-0.706[b]	0.402	-0.139	0.247
π	0.012	0.061	-0.030	0.102	0.072	0.049
Obs	40		40		40	
Chi-2 all	132.452	0.000	493.438	0.000	138.950	0.000
Chi-2 age	9.115	0.058	9.077	0.059	48.433	0.000
nR^2	3.747	0.290	6.695	0.153	2.988	0.560
Q-stat. 1	0.002	0.968	0.148	0.518	1.743	0.187
2	1.248	0.536	0.424	0.809	2.633	0.268
3	1.542	0.673	0.654	0.884	3.080	0.379
4	2.158	0.707	0.656	0.957	6.259	0.181

Notes: see table 3.1. The nR^2-test, sometimes labelled the Sargan test, is a test of overidentifying restrictions, testing the joint hypothesis that the model is correctly specified and that the instruments are valid. For a description of this test see e g Davidson&MacKinnon (1993). Instrument list: the contemporaneous age shares and population growth variable, and the economic variables lagged once and twice. The growth rate of the investment share lagged twice was not included among the instruments in the Danish regression since this made the nR^2-test significant.

Table 3.2 above shows the results of the IV estimations for Denmark, Finland, and Sweden. Since the general specification did not work on Norway, results are not reported below. The results from the IV estimations for the other three countries reinforce the inference drawn from the regressions in section 3.1. The age variables are jointly significant in all regressions, and for Denmark and Sweden the signs and relative effects of the age shares are basically the same as in the OLS regressions. Thus, simultaneity bias is no serious problem for these two countries.

There is some change in the estimates of the age-share coefficients for Finland in the IV estimation, with the relative impacts of the different age shares now more in line with the Swedish case. However, not much can be inferred from this since none of the age coefficients are individually significant.[11] Like the age-share coefficients, the results regarding the economic variables for Denmark and Sweden are quite similar to the results in table 3.1. Judging from the test of overidentifying restrictions there is no problem with the instruments in any of the regressions. So, the conclusion from this section must be that the significance of the age structure is not lost when a potential simultaneity bias is corrected. In fact, this correction does not seem to affect the estimates in any major way.

3.4 Ridge regressions

A potential problem in comparing relative sizes and signs of the age-share coefficients is that they might be imprecisely estimated, i e have the wrong sign or be of implausible magnitudes, since these regressors are highly collinear. This is a general problem when using measures of the age distribution, as opposed to single age shares, in regressions; a problem which has been dealt with in different ways in the literature[12]. Here of course, it was done by excluding the youngest age share in the regressions. However, since the age shares are in logarithms, all age shares could be included without a perfect collinearity between their sum and the constant.

In the light of the results of the preliminary investigation in section 2, the question is whether the sizes and signs of the age coefficients in the earlier regressions will change radically when the youngest age share is included in the estimations, i e when all components of the age distribution are included. However, this is not easily verified since the coefficients from regressions with all age shares present most likely will suffer from the collinearity problem, which usual measures of multicollinearity, such as the condition number[13], indicate.

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[11] However, just as in the OLS regression, the inclusion of the youngest age share in the regression (not reported) alters this, making the middle three significant using a 10% critical value and the youngest bordering this level.

[12] Two examples: McMillan & Baesel (1990) use an age variable consisting of the ratio between the people aged 35-64 and the sum of the people aged 15-34 and 65+. Fair & Dominguez (1991) use an ingenious method with which they can reduce the number of age variables to two by imposing restrictions on the total and relative effect of the age shares. Both procedures have been tried here, but without success.

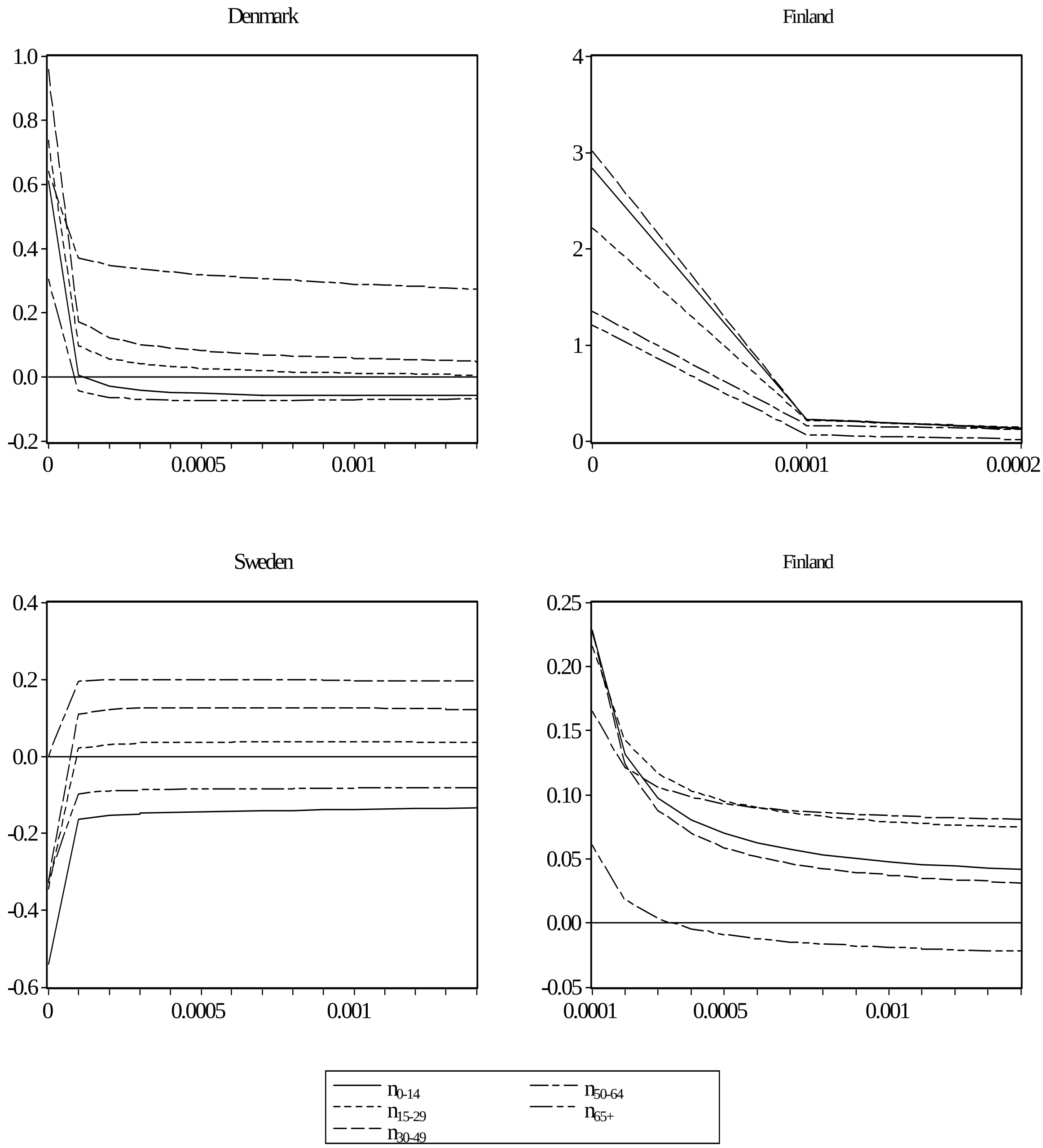
[13] The condition-number measure of multicollinearity is the square root of the ratio of the largest to the smallest characteristic root of the normalized moment matrix. According to the literature, values in excess of 20 suggest potential problems. This number is exceeded by far by all three cases in the text.

There are different ways of dealing with this problem. One way is to use ridge regressions (e g Greene 1993, ch 9.2.4; Judge et al 1985, ch 22). The point of this procedure is to focus on the mean square error and trade the unbiased OLS estimator for a biased one with, possibly, a smaller mean square error. In one version, the ridge regressor is formed by adding an arbitrarily chosen scalar *k* to the diagonal of the ordinary X'X-matrix of the OLS estimator. In applications, *k* is usually set to some small number and successively increased. The estimated coefficients, which are shrunk towards zero as *k* is increased, are then plotted against *k* to form a ridge trace. A certain *k* is selected where the coefficients have stabilized along the trace, and the estimates for this *k* will be the ridge-regression estimates. The value of *k* is chosen on the basis of criteria such as stability of estimated coefficients as *k* increases, reasonable signs, plausible magnitudes of the coefficients, and reasonable sum of squared residuals.

The estimator is biased but with smaller variance than that of the OLS estimator, and there is a possibility that the chosen value of *k* will be one where the mean square error is less than for the OLS estimator. However, even though it can be shown that there always exists a $k > 0$ for which the ridge estimator has a smaller mean square error, there is no way of knowing whether or not this *k* has been attained since it will be a function of the unknown parameters which are to be estimated. A number of methods for letting data help select a value of *k* have been suggested, but this makes *k* stochastic and the gain in mean square error no longer guaranteed. This, together with the limited possibility of hypothesis testing, is the major drawback of ridge estimations.

Nevertheless, it is of interest here to include the youngest age share in the regressions in order to investigate what effect this will have on the estimates of the other age shares. Hence, the general specification is augmented with the youngest age share as an experiment to see whether the relative magnitudes and signs of the OLS estimated age coefficients in section 3.1 change, and to see what the pattern is when the collinearity problem is mitigated.

Figure 3.1 Ridge traces for the age coefficients.



Notes: For ease of exposition two graphs for Finland are displayed; the upper showing ridge traces which start with the estimates for k=0, i e the OLS estimates, and the lower showing traces which start with the first k-value.

Figure 3.1 above shows ridge traces for the age parameters for Denmark, Finland, and Sweden, i e the ridge estimates on the vertical axis for different values of *k* on the horizontal axis.[14] Comparing the estimated coefficients in table 3.1 with the coefficients in figure 3.1 when *k* = 0 (also in appendix A.6), i e the OLS estimates, it is quite obvious that the inclusion of the youngest age share changes the regression results dramatically, and judging by the signs and magnitudes of e g the Finnish coefficients, the collinearity problem is striking.[15]

The introduction of *k* reduces the size of the estimates considerably and alters signs on a number of individual parameters. It also seems as just the introduction of a very small *k* is enough to stabilize the estimates and yield magnitudes of the coefficients more in line with the values in the OLS regressions in section 3.1. Furthermore, comparing these magnitudes relative one another they remain about the same as in the regressions above. For Denmark the notion that it is the middle aged who has the largest influence on growth is further strengthened. The parameters for the youth and the retired are both negative and have similar traces.

This is also true for Sweden, but unlike Denmark the middle aged influence is not as pronounced. The coefficient estimates for the prime, and the middle aged stay close to each other all through the trace, although the distance between the estimates is remarkably stable. For Finland the relative pattern of the age parameters looks different. Here, it seems to be the young adults and middle aged who are the most influential. Unlike Denmark and Sweden the parameter for the youth is positive so the negative impact comes solely from the retired. In conclusion, the results from the ridge estimates support the results of the regressions in earlier sections; the inclusion of the youngest age share does not change the relative pattern of the age coefficients in these regressions to a large extent when the collinearity problem is mitigated by ridge regressions.

[14] Results from the estimations including all age shares, and *k* = 0, are reported in appendix A.6.
[15] However, as mentioned in section 3.2, all age shares are now individually significant in the Finnish case, and the RESET-test is no longer significant.

4. Summary and concluding remarks

The purpose of this paper has been to investigate whether a country's demographic situation affects the aggregate economic performance, and more specifically whether the age distribution influences GDP growth. Such effects have been found over longer time periods and in panels of countries in other studies. But the focus here has been on whether such effects are discernible in annual data for individual countries, and judging by growth regressions on data for the Nordic countries presented here, there are such age-structure effects.

Using data for Denmark, Finland, Norway, and Sweden, a preliminary investigation with a simple age-share specification indicated a positive influence on growth from the prime and middle aged, which might be explained by age effects via human-capital accumulation, but also by effects via life-cycle savings. Results from estimations of a typical growth specification augmented with age variables and more volatile economic variables showed a good fit on the Danish, Finnish, and Swedish data, with age shares jointly significant for all countries. Inclusion of time-specific dummies for the oil crises and the slump in the beginning of the 90s did not affect the significance of the age variables.

Since there are strong theoretical reasons to suspect a simultaneous determination of the economic variables and GDP growth, the same specification wasreestimated using an instrumental-variable estimator. The results showed no major difference from the OLS regressions. In order to investigate whether there would be large changes in the age coefficients if the youngest age group was included, experiments with ridge regressions were made to mitigate the collinearity which obscured the results from regressions including all age shares. The results showed basically the same pattern as in the earlier regressions.

Regarding the pattern of the age-share impact, the results from the regressions suggest, as hypothesized, that it is the prime and middle aged who have the highest positive effect on growth, while the coefficient for the retired group is negative in all regressions. However, the clear, common pattern of the age coefficients, which was found for Denmark, Norway, and Sweden in section 2, was not crystallized in the regressions in section 3. A reason for this might be the aggregation of the age shares; the results might be more clear-cut with a finer measure of the age distribution.

There are, however, other reasons why the pattern for the different countries might differ from each other. First of all, income growth might not be the only variable which is influenced by the age structure. There is of course the life-cycle effect on savings, which might translate into an effect on investments, but one can also argue for effects on a number of othermacroeconomic variables, including both government consumption, and the rate of inflation. Such dependence will certainly make detection of a clear age pattern in the regressions above more difficult.

Secondly, the general specification does not account for country-specific features; e g incomplete account for effects of oil price changes is probably a major reason for the poor fit in the Norwegian case. Even though some of these individual features probably could be accounted for with a more systematic search for individual specifications, it would be difficult to take into consideration institutional aspects. Such things as design of the social security program, tax system etc, will affect the way in which the age-structure impact is propagated through the economy. For example, the tax system should be important for the savings link since it affects decisions regarding both the level and composition of savings, while the form and quality of the educational system should be important for the human capital link.

Although differences in the institutional framework might obstruct the detection of a common pattern in the regressions here, further investigations of these differences, and their connection to the age structure, might help to reveal the primary channel(s) through which the age distribution affects macroeconomic variables. In order to fully exploit the age distribution's potential as a forecasting tool, such efforts should certainly be worth while.

5. References

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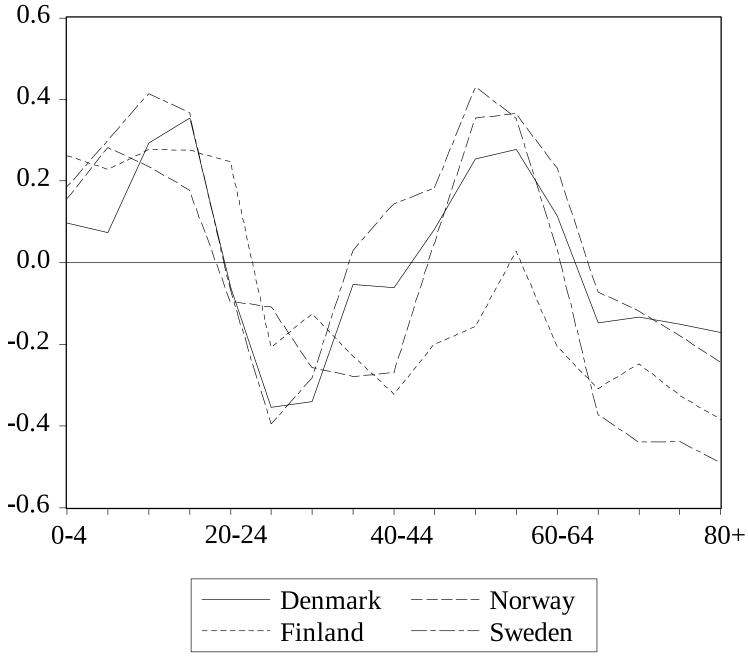
Appendix

A.1 Correlations between age shares and the growth rate of GDP per capita



Data sources: see appendix A.2. Sample period 1950-1992.

A.2 Data sources and variable definitions

All data for the non-age variables were taken from Penn World Table 5.6 (Summers and Heston[1991]) which is available from the NBER web-site http://www.nber.org/pwt56.html. The definitions are the following:

y : log of real GDP per capita (PWT: ln(rgdpl))
i : log of the investment share of GDP (PWT: ln(0.01*i))
w : growth rate of the population (PWT: $\ln(pop)-\ln(pop)_{-1}$)
nfb: net foreign balance (PWT: 0.01*(100-c-g-i))
g: log of share of public consumption expenditure (PWT:ln(0.01*g))
π: inflation rate (PWT: $\ln(p)-\ln(p)_{-1}$)

Data on the population divided into age shares were taken from the official statistics of each country.

A.3 Correlation matrices for the variables in the general specification

Denmark

	Δy	n_{0-14}	n_{15-29}	n_{30-49}	n_{50-64}	n_{65+}	x	Δi	Δnfb	Δg	π
Δy	1.000										
n_{0-14}	0.156	1.000									
n_{15-29}	-0.062	-0.547	1.000								
n_{30-49}	-0.147	-0.408	-0.489	1.000							
n_{50-64}	0.312	0.496	0.299	-0.911	1.000						
n_{65+}	-0.141	-0.940	0.667	0.145	-0.292	1.000					
x	0.129	0.818	-0.323	-0.380	0.527	-0.859	1.000				
Δi	0.894	0.139	-0.101	-0.071	0.183	-0.136	0.098	1.000			
Δnfb	0.308	0.231	-0.258	0.051	0.017	-0.276	0.218	0.314	1.000		
Δg	-0.684	0.254	0.084	-0.245	0.074	-0.120	0.286	-0.684	-0.096	1.000	
π	0.005	-0.026	0.169	-0.124	0.099	0.015	0.236	0.012	-0.277	0.009	1.000

Finland

	Δy	n_{0-14}	n_{15-29}	n_{30-49}	n_{50-64}	n_{65+}	x	Δi	Δnfb	Δg	π
Δy	1.000										
n_{0-14}	0.291	1.000									
n_{15-29}	0.199	-0.059	1.000								
n_{30-49}	-0.307	-0.626	-0.679	1.000							
n_{50-64}	-0.164	-0.699	0.218	0.109	1.000						
n_{65+}	-0.318	-0.994	-0.005	0.649	0.718	1.000					
x	-0.118	0.567	-0.426	0.036	-0.741	-0.559	1.000				
Δi	0.818	0.229	0.062	-0.145	-0.223	-0.250	-0.044	1.000			
Δnfb	0.230	0.275	-0.016	-0.110	-0.314	-0.295	0.139	0.264	1.000		
Δg	-0.887	-0.203	0.004	0.069	0.226	0.226	0.015	-0.847	-0.163	1.000	
π	0.260	-0.088	0.114	0.012	0.024	0.064	-0.055	0.223	0.121	-0.182	1.000

Norway

	Δy	n_{0-14}	n_{15-29}	n_{30-49}	n_{50-64}	n_{65+}	x	Δi	Δnfb	Δg	π
Δy	1.000										
n_{0-14}	0.276	1.000									
n_{15-29}	-0.010	-0.731	1.000								
n_{30-49}	-0.295	-0.024	-0.600	1.000							
n_{50-64}	0.419	0.779	-0.226	-0.620	1.000						
n_{65+}	-0.136	-0.884	0.851	-0.402	-0.416	1.000					
x	0.037	0.771	-0.755	0.397	0.303	-0.896	1.000				
Δi	0.163	0.269	-0.123	-0.089	0.268	-0.220	0.136	1.000			
Δnfb	-0.085	-0.004	0.175	-0.212	0.122	0.070	0.062	-0.031	1.000		
Δg	-0.355	0.128	0.005	-0.010	0.076	-0.164	0.141	0.029	0.021	1.000	
π	-0.014	-0.003	0.093	-0.045	-0.036	-0.026	0.193	0.191	-0.041	-0.028	1.000

Sweden

	Δy	n_{0-14}	n_{15-29}	n_{30-49}	n_{50-64}	n_{65+}	x	Δi	Δnfb	Δg	π
Δy	1.000										
n_{0-14}	0.371	1.000									
n_{15-29}	-0.076	-0.445	1.000								
n_{30-49}	0.032	0.226	-0.875	1.000							
n_{50-64}	0.394	0.463	0.425	-0.675	1.000						
n_{65+}	-0.444	-0.963	0.417	-0.312	-0.414	1.000					
x	0.084	0.399	-0.043	0.215	0.087	-0.525	1.000				
Δi	0.590	0.108	-0.129	0.180	-0.026	-0.166	0.087	1.000			
Δnfb	0.106	-0.114	-0.009	0.051	-0.114	0.098	0.010	0.292	1.000		
Δg	-0.519	0.152	0.064	-0.052	0.029	-0.122	0.266	-0.546	-0.133	1.000	
π	0.095	-0.014	0.092	0.000	-0.081	-0.019	0.235	0.143	-0.146	-0.074	1.000

A.4 Regressions with both a contemporaneous and lagged effect from the non-demographic variables

	Denmark		*Finland*		*Norway*		*Sweden*	
Variable	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
constant	1.026[a]	0.465	-0.109	0.431	1.364	1.119	0.866[a]	0.274
$n_{15\text{-}29}$	-0.024	0.134	0.113	0.084	0.338[a]	0.139	0.300[a]	0.050
$n_{30\text{-}49}$	0.155	0.117	0.084	0.138	0.264	0.203	0.368[a]	0.078
$n_{50\text{-}64}$	0.391[a]	0.170	0.022	0.121	0.358	0.239	0.247[a]	0.073
$n_{65\text{-}}$	0.032	0.072	-0.066	0.053	-0.047	0.082	-0.034[b]	0.018
x	0.019	0.170	-0.105[a]	0.045	-0.036	0.143	-0.164[a]	0.050
Δi	0.212[a]	0.026	0.0002	0.061	-0.008	0.021	0.096[a]	0.031
Δi_{-1}	0.049	0.050	-0.020	0.038	0.003	0.018	-0.030	0.028
Δnfb	0.001[b]	0.001	-0.001	0.0005	-0.001[b]	0.001	0.002[a]	0.001
Δnfb_{-1}	-0.002	0.001	-0.001	0.001	-0.0001	0.0003	0.002[a]	0.001
Δg	-0.177	0.140	-0.728	0.133	-0.311	0.225	-0.204[a]	0.066
Δg_{-1}	0.162	0.178	-0.184	0.117	-0.033	0.127	0.046	0.057
π	-0.002	0.028	0.089[a]	0.042	-0.021	0.037	0.018	0.025
π_{-1}	-0.026	0.022	-0.052	0.045	-0.018	0.062	0.049[a]	0.024
Obs	41		41		41		41	
R^2 *adj.*	0.793		0.872		0.192		0.726	
Chi-2 all	568.727	0.000	615.786	0.000	48.173	0.000	433.881	0.000
Chi-2 age	12.272	0.015	32.223	0.000	17.752	0.001	86.110	0.000
RESET	0.815	0.454	0.472	0.629	3.043	0.066	0.175	0.841
White	18.824	0.844	25.334	0.500	29.699	0.280	21.725	0.704
DW	2.249		2.287		1.494		2.271	
B-G LM	7.894	0.019	1.651	0.438	3.714	0.156	7.209	0.027
Q-stat. 1	0.797	0.372	1.096	0.295	2.190	0.139	2.103	0.147
2	4.209	0.122	1.097	0.578	2.479	0.290	3.554	0.169
3	4.327	0.228	4.583	0.205	4.639	0.200	3.564	0.313
4	4.341	0.362	5.692	0.223	5.032	0.284	6.011	0.198

Notes: see table 3.1.

A.5 Regressions with period-dummy variables

	Denmark		*Finland*		*Norway*		*Sweden*	
Variable	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
constant	0.364	0.332	-0.851	0.597	3.940[a]	1.448	0.763[b]	0.382
$n_{15\text{-}29}$	0.100	0.088	-0.136	0.117	0.438[a]	0.103	0.105	0.084
$n_{30\text{-}49}$	0.146[b]	0.086	-0.261	0.183	0.648[a]	0.220	0.213[a]	0.101
$n_{50\text{-}64}$	0.380[a]	0.135	-0.094	0.145	0.725[a]	0.220	0.227[a]	0.089
$n_{65\text{-}}$	-0.061	0.041	0.053	0.065	0.156	0.096	0.006	0.027
x	-0.195[b]	0.104	-0.102	0.066	0.249	0.179	-0.040	0.056
Δi	0.187[a]	0.032	0.003	0.061	0.029	0.030	0.065[a]	0.030
Δnfb	0.002[a]	0.001	0.001	0.001	-0.001[a]	0.0004	0.0004	0.0005
Δg	-0.113	0.086	-0.674[a]	0.101	-0.230	0.202	-0.198[a]	0.074
π	0.033[b]	0.019	0.054	0.032	-0.028	0.047	0.030	0.021
oil dummy	-0.020[a]	0.005	-0.016[a]	0.007	0.023[b]	0.012	-0.018[a]	0.006
90s dummy			-0.039[a]	0.013	-0.026[a]	0.007	-0.018[a]	0.007
Obs	42		42		42		42	
R^2 *adj.*	0.838		0.869		0.405		0.669	
Chi-2 all	610.544	0.000	1426.542	0.000	257.125	0.000	313.142	0.000
Chi-2 age	12.963	0.011	10.780	0.029	44.322	0.000	42.848	0.000
RESET	1.025	0.238	0.432	0.653	1.831	0.179	0.287	0.753
White	9.498	0.964	19.065	0.518	17.600	0.614	24.635	0.216
DW	2.167		2.279		2.017		2.089	
B-G LM	4.422	0.110	1.261	0.532	2.697	0.260	2.699	0.259
Q-stat. 1	0.433	0.511	1.105	0.293	0.045	0.833	0.570	0.450
2	3.034	0.219	1.108	0.575	2.194	0.334	1.963	0.375
3	3.035	0.386	3.541	0.315	2.762	0.430	4.851	0.183
4	3.124	0.537	3.587	0.465	3.079	0.545	6.704	0.152

Notes: see table 3.1. The oil-dummy variable is equal to one for the years 1974-75 for Denmark, 1976-77 for Finland and Sweden, and 1972-79 for Norway. The "90s" dummy is equal to one for the period 1990-92 for Finland, 1991-92 for Sweden, and 1987-89 for Norway.

A.6 Regressions including the youngest age share (ridge regressions with *k* = 0)

	Denmark		Finland		Sweden	
Variable	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
constant	5.152	3.308	16.619[a]	4.970	-2.704	5.100
$n_{0\text{-}14}$	0.610	0.423	2.827[a]	0.864	-0.541	0.772
$n_{15\text{-}29}$	0.737	0.442	2.215[a]	0.643	-0.345	0.762
$n_{30\text{-}49}$	0.958	0.565	3.012[a]	0.886	-0.328	0.881
$n_{50\text{-}64}$	0.641	0.250	1.353[a]	0.359	0.0003	0.374
$n_{65\text{-}}$	0.305	0.257	1.203[a]	0.407	-0.322	0.453
x	0.007	0.157	0.003	0.053	-0.091[b]	0.048
Δi	0.181[a]	0.036	0.053	0.042	0.080[a]	0.028
Δnfb	0.002[a]	0.001	0.001	0.001	0.001	0.001
Δg	-0.230[b]	0.120	-0.641[a]	0.084	-0.197[a]	0.096
π	0.016	0.020	0.065[a]	0.021	0.026	0.020
Obs	42		42		42	
R^2 *adj.*	0.827		0.882		0.627	
Chi-2 all	351.618	0.000	295.295	0.000	136.476	0.000
Chi-2 age	10.922	0.053	47.757	0.000	69.145	0.000
RESET	0.936	0.404	1.157	0.328	0.320	0.729
White	10.003	0.953	14.818	0.734	23.449	0.218
DW	2.121		2.214		1.985	
B-G LM	4.671	0.097	0.803	0.669	3.173	0.205
Q-stat. 1	0.295	0.587	0.620	0.431	0.309	0.579
2	3.189	0.203	0.625	0.732	2.485	0.289
3	3.216	0.359	2.392	0.495	4.616	0.202
4	3.252	0.517	2.687	0.611	6.612	0.158

Notes: see table 3.1.