Can demography improve in‡ation forecasts? The case of Sweden.[¤]

Mattias Bruér[y]

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Abstract

Time series regressions indicate that age structure has signi…cant forecasting power on Swedish in‡ation. The results agree with a Phillips-Okun framework, assuming that the demographic composition a¤ects productivity. The relative age e¤ects are also relatively well in accordance with what could be expected from life-cycle theory. In the forecasting exercise the age model outperforms the estimated benchmarks; i.e. two autoregressive models, an ARIMA and the 2 per cent forecast corresponding to the stipulated in‡ation target. The age model is also considerably better than the consensus forecasts and it is equal in merit with a general VAR model that has been used by the Riksbank (Bank of Sweden). We conclude that the source of information embedded in the age shares is something the Riksbank should consider when conducting monetary policy. When extending the forecasting horizon, the age model predicts a signi…cant rise in the in‡ationary pressure after 2005 when the big baby boom cohort of the 1940s enters retirement.

Keywords: In‡ation forecasting, Demography, Life-cycle hypothesis

JEL codes: E31; J10; J11

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[y]Correspondence: Department of Economics, Uppsala University, Box 513, S-751 20 Uppsala. E-mail: mattias.bruer@nek.uu.se.

1 Introduction

Many central banks such as Sveriges Riksbank (Bank of Sweden) have an explicit in‡ation target as the guideline for the monetary policy. In order to properly conduct in‡ation-targeting a high degree of foresight is required since policy actions to curb in‡ation generally are believed to take e¤ect after a lag of 12 to 24 months. Moreover, from the viewpoint of the Riksbank it is important to distinguish changes in the general direction of in‡ation from transitory ‡uctuations of the in‡ation rate. The …rst case should be carefully looked upon, whereas transitory changes should not cause the Riksbank to intervene. This paper shows that demography has signi…cant forecasting power on in‡ation. Demographic trends should therefore have a potentially important role when assessing the future in‡ationary pressure.

Forecasting in‡ation by demography is facilitated by the fact that age shares can be predicted with small forecasting errors up to long horizons, relative to predictions of other macroeconomic variables. In order to evaluate these in‡ation forecasts some benchmark models are considered. The chosen alternatives are autoregressive models, an ARIMA and the 2 per cent forecast corresponding to the annual in‡ation target. The age models are also compared with the consensus forecasts and a general VAR speci…cation that has been used by the Riksbank. In most cases the results from the out-of-sample forecasting exercise are in favour of the age models. The age models do not only perform well in the medium run, but are very accurate at the one- to two-year horizons.

The life-cycle hypothesis [Modigliani & Brumberg (1954)] and the human capital theory [see e.g. Becker (1962), Mincer (1962) and Mankiw, Romer & Weil (1992)] predict that demography could in‡uence economic aggregates. In the …rst empirical studies on this subject, the e¤ect on savings was investigated. Examples are Berg & Bentzel (1983), Mason (1987), Horioka (1989, 1991) and Kelley & Schmidt (1996). Numerous studies have found that demography has a signi…cant impact on growth. Examples are Malmberg (1994), Andersson (2000a) and Lindh & Malmberg (1999a) who identi…ed age e¤ects on growth for Swedish, Nordic and OECD post-war data. Demographic e¤ects on growth, real interest rates, unemployment and in‡ation have been documented e.g. by McMillan & Baesel (1990) for the US and by Lenehan (1996) for Australia. Age e¤ects on in‡ation have also been established for Swedish and OECD data, see Lindh (1999) and Lindh & Malmberg (1998) respectively.

The structure of the rest of the paper is the following. In section two some of the theoretical e¤ects of demography on in‡ation are discussed. In the third section the empirical study starts o¤ with data description and estimation. Section four examines the robustness of the results and in section …ve the forecasting exercise commence. Section six concludes.

2 Theoretical channels

If demography a¤ects in‡ation via the demand side, the life-cycle hypothesis and the IS-LM model may be utilized to describe the forces at work. It is also conceivable that a changing demographic pattern a¤ects in‡ation via the supply side since the potential output, y^*; should depend on the human resources available in the economy. If demography in‡uences aggregate supply, the Phillips-Okun framework may be utilized to link demography to in‡ation. Evidence consistent with both of these channels will be presented in the empirical analysis.

2.1 Demand side e¤ects

To explain why the demographic structure a¤ects in‡ation, the life-cycle hypothesis is a natural starting point. According to the life-cycle hypothesis economic agents smooth their consumption over life. The model predicts that wealth will be accumulated during the productive part of the life-cycle and decumulated during retirement. During life, agents will be both net-savers and net-borrowers.

Demography may a¤ect in‡ation via its e¤ects on aggregate savings. These demand side e¤ects can be illustrated by the standard IS-LM model and is most easily seen assuming a closed economy. Let the equations (2.1) and (2.2) represent the IS curve and the LM curve, respectively.

$$y = c(y - t) + I(r) + g \tag{2.1}$$

$$\frac{m}{p} = L(r; y) \tag{2.2}$$

In (2.1) and (2.2) $y; c; t; I; g; m$ and p are output, consumption, taxes, investment, government spending, money supply and price level. Assume that the economy is in its long run equilibrium where y is at its potential or natural level, y^*. If there is a positive shock in a net-saving group, say the middle-aged (here de…ned as the fraction of people in the age brackets 50 - 64), the life-cycle model predicts that saving will increase and consumption decrease. The increase in saving can be interpreted as a contractionary shift in the IS curve, causing r and y to fall. The short run equilibrium will be where the new IS curve crosses the LM curve. At the corresponding price level the quantity of output demanded will be below the natural rate. Eventually the low demand for goods and services will cause the price level to fall, raise real money balances and shift the LM curve downward until demand equals y^*: At the new (lower) price level the quantity demanded will be sufficient to keep y at its natural level. The economy will once again be at the long run equilibrium where the IS and LM curves intersect at y^*. This stylized exercise shows that if there is a growing fraction of people in a net-saving phase, ceteris paribus, one would expect the price level to fall.

2.2 Supply side effects

Full capacity output, y^*, should depend on the human resources in the economy. The human resources are in turn closely related to the age-structure and to the development of productivity growth. The fraction of the population in their working years is expected to be positively related to potential output, whereas people outside the workforce should inflict the opposite relationship. Middle-aged people have accumulated valuable experience in the course of their working life which should affect productivity positively. Likewise, it is conceivable that people in their 30s relatively easily have assimilated the rapid technical progress in recent years. Ceteris paribus, a more productive age-profile would imply that potential output could be raised without requiring a larger input of production factors. The mechanism also indicates that the age-structure is a relevant factor when assessing the future path of inflation, e.g. via the Phillips curve (see equation (2.3)). Once again, assume that there is positive shock in the middle-aged. This would increase productivity and, in turn, y^*: Increases in y^* would raise the amount of resources available to meet the current demand and counteract the risk of bottlenecks in the economy. Consequently, $y - y^*$ would fall, causing inflation to fall in (2.3). The reverse relationship would be expected if there is an increase in the newly retired (here defined as the people in the age brackets 65 - 74).

$$\pi = \alpha + \beta_1 (y - y^*) + \pi^e + \varepsilon \qquad (2.3)$$

In (2.3) π^e is expected inflation and ε is a supply shock, e.g. an unexpected change in factor prices or oil prices. Studying (2.3) we see that the output gap consists of a demand side component, y, and a supply side component, y^*. If the fraction of middle-aged increases, we would expect a decrease in y and an increase in y^*. Irrespective of whether demand or supply side effects dominate, (2.3) suggests that the effects on inflation would work in the same direction.

One objection to the above discussion is that if a demographic shock is observed, the Riksbank should counteract its effect on future inflation.

If demographic changes is incorporated in the information set, demography should simply not have forecasting power on in‡ation. However, the Riksbank has not recognized the age e¤ects on y ¡ y¤, and in turn on in‡ation, until relatively recently [see the In‡ation Report (2000:3)].

3 Empirical study

It has been argued that a general to speci…c approach should be adopted when building econometric models [see e.g. Charemza & Deadman (1997)]. Economic theory tells us that variables such as the money supply, the output gap and interest rates are related to the in‡ation rate. However, the general to speci…c approach should primary be used when the aim is to identify a structural model. When forecasting is the main attraction Clements & Hendry (1998) among others argue that a greater premium should be given to parsimonious speci…cations since considerations like maximizing the R^2 or the likelihood would yield better forecasts only in a stationary, well-behaved world. When this is not plausible, the in-sample …t will be overemphasized resulting in poorer forecasts. Further, forecasting in‡ation using variables that themselves need to be forecasted may double the forecasting uncertainty [Tashman et al. (2000)]. Therefore we choose not to include other macroeconomic variables in the age models.

3.1 The demographic pro…le

In this paper, six age groups will be de…ned in order to approximate the differences in economic behavior over the life-cycle. Assuming only two states of life, one active phase and one passive, is likely to be too restrictive when trying to capture the economic forces at work. However, it should be admitted that the exact denomination is arbitrary and only one of many optional ways to represent the demographic pro…le. For example, demography has often been represented by dependency ratios or averages in the empirical literature. These formulations do not come without a cost. When using, for instance, the young and elderly relative to the total population only a limited part of the information in the age pro…le is utilized. Accordingly, one may have di¢culties explaining important dynamics that arise from the interaction between di¤erent cohorts, since a signi…cant part of the active life is ignored.[1]

[1] McMillan & Baesel (1990), Higgins (1998) and Lindh & Malmberg (1999b) have all proposed alternative ways of empirically representing the demographic pro…le.

If demography a¤ects in‡ation mainly via changes in productivity and/or stylized life-cycle consumption, the expected impact of the di¤erent age shares could be conjectured as follows. Young adults are in the age brackets 15 - 24. Young adults are in education, family formation and/or working, often at low-paying jobs. Young adults have positive e¤ects on housing investment, see Fair & Dominguez (1991) and Lindh & Malmberg (1999b). The group behavior is probably di¤erent today compared to the 1960s and 1970s. Nowadays young adults engage in education for a longer time period, thereby shifting family formation and work to a later phase of life. Today they are probably net-borrowers and also non-productive if they do not participate in the workforce. Consequently, young adults may in‡ict an in‡ationary pressure today that need not hold some decades ago. In the age brackets 25 - 49 we …nd the prime-aged. This group is characterized by family raising, home investment and probably high productivity.

The middle-aged between 50 - 64 are presumably highly productive since they have accumulated valuable experience during the course of their working life. Since the middle-aged earn the most and are past their family years they are most probably net-savers. Saving must also increase in order to maintain a stable consumption pattern when retired, since income then decreases. Andersson (2000b) has shown that the middle-aged (and the newly retired) are reallocating real estate investment into …nancial assets. It is likely that high …nancial savings will boost capital accumulation, which in turn may stimulate business investment and $y^{¤}$. A study by Lindh & Malmberg (1999b) con…rms that the group has a positive e¤ect on business investment.

In order to compensate for the lower income, the newly retired (aged 65 - 74) are reallocating saved assets into consumption. Further, individuals passing from active life to retirement will a¤ect productivity and the supply of labor negatively. The economic activity of elderly, aged 75 and above, is low and consumption is to a large extent devoted to medication and health care. Finally, children aged 0 - 14 were excluded in the empirical analysis since when a model contains an intercept all groups cannot be incorporated since they sum to unity. If economic activity contemporaneously a¤ects the birth rate, the exogeneity assumption is more likely to be violated for this group, as pointed out by Easterlin (1968).

The input data on the age shares has been supplied by Statistics Sweden and refers to the population on December 31 any given year.[2] The original data set was divided into 19 …ve-year cohorts except for the oldest who were given as 90 years old and above. These cohorts have been aggregated into the six groups de…ned above. An important reason for aggregating is

[2] Information on all variables in this paper are given in the Data Appendix.

that the complete set of 19 five-year cohorts would induce a severe case of multicollinearity. The model would be poorly identified, implying a near singular Hessian near the true coefficient vector [Davidson & MacKinnon (1993)]. The age of graduation, marriage, family setting and retirement also tend to shift over time, preventing us from getting stable estimates of every cohort. Multicollinearity will be reduced by using a set of fewer age shares each covering a longer time span. Multicollinearity may still be a problem, causing the estimated coefficients to be dependent due to cross-correlated age shares. At the worst multicollinearity may inflict sign reversals whereas blown-up estimates represent a milder consequence.[3] One fairly sophisticated way of circumventing the potential problem induced by multicollinearity was proposed by Fair & Dominguez (1991). The disadvantage of their method is that the restriction, constraining the age coefficients to a polynomial, often is rejected empirically. Lindh & Malmberg (1999a) argue that the reason may be the sudden change in economic behavior when retired.

Since we have monthly observations of the annualized inflation rate, the age shares were transformed into monthly series using a quadratic interpolation method. Interpolating age groups have been done frequently in empirical applications. Examples are McMillan & Baesel (1990) and Lenehan (1996). The reason for not using linear interpolation as in these studies is that such a method is likely to induce excess serial correlation in the residuals. The quadratic interpolation method should also be preferred when the source data is fairly smooth. It should be emphasized that using quarterly or yearly data when monthly observations are available implies that potentially valuable information would be thrown away. Since inflation does not exhibit any smooth seasonal pattern, time-aggregating would also introduce unnecessary distortions [Attanasio, Picci & Scorcu (2000)]. In Figure 1 the actual and projected age shares are illustrated up to 2020.

In the empirical analysis the age shares will be lagged twelve periods (i.e. 1 year) to ensure that the variables are predetermined with respect to inflation. When studying the estimated models it is also very important to note that the age coefficients can only be interpreted relative to each other. Consequently, individual age shares need not have negative coefficient estimates to inflict a deflationary pressure, and vice versa. Further, some identification assumptions are required to separate the age coefficients from the intercept.

[3] When forecasting, multicollineartity need not be too harmful. Even though individual estimates may be imprecise, stability of the forecasts will not necessarily be affected.

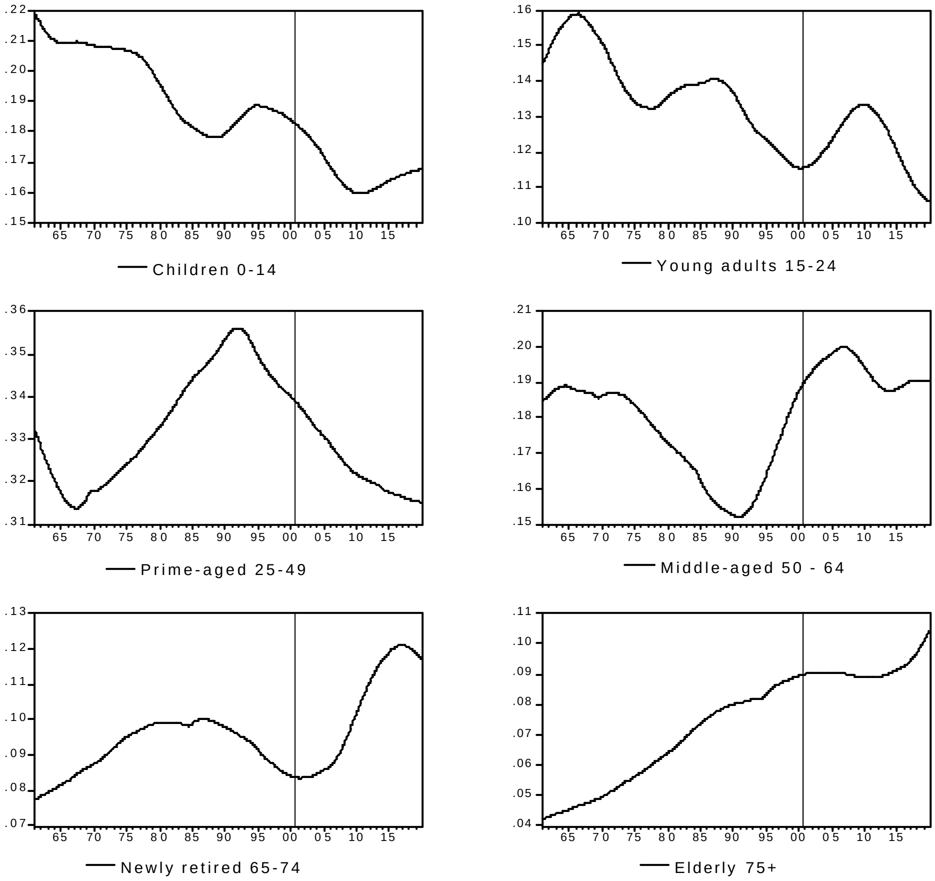

Figure 1: The Swedish age-share transition, 1960:1 - 2019:12.

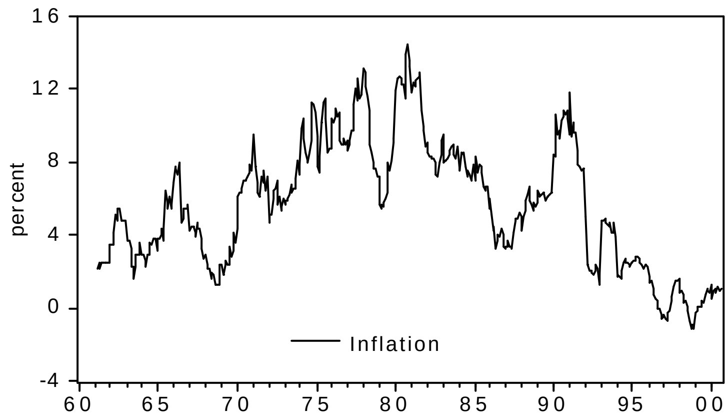

Figure 2: Swedish inflation 1961:3 - 2000:8.

3.2 Unit root properties

Monthly observations on the consumer price index (cpi) was supplied by the Riksbank. The inflation rate was computed as $\ln(cpi_t/cpi_{t-12})$: By visual examination it is evident that the inflation rate has been fairly unstable and it is not obvious that inflation is an integrated process during the period in question. Until the early 1980s there was an upward-sloping stochastic trend. Except for a few spikes, the inflation trend has been negative for the second half of the sample. In recent years the inflation rates have often been below the lower bound of the target interval. The monthly annualized inflation rate has occasionally even been negative in 1996 - 1999. One may argue that inflation rates outside the target interval indicate that systematical forecasting errors may have been made. If the Riksbank had access to reliable inflation forecasts there are no obvious reasons why inflation should diverge from the target interval. However, if the loss function of the Riksbank embraces output, temporary divergences from the tolerance interval may occur.

If all variables are I(1), the general recommendation is to difference in order to get stationary series rather than estimating in levels. When not differencing, one may run the risk of spurious regression. This issue will be considered in depth in the specification analysis. When we are dealing with age shares things get a little more complicated. Firstly, studying Figure 1 we see that at least some age shares are trended and probably not stationary. In fact, traditional tests like the augmented Dickey-Fuller and the Phillips-Perron were unable to reject the null hypothesis of a unit root for all groups, see Table A.1.[4] Regarding inflation, unit root tests were also unable to reject the null. Given these results, one may advocate estimating in differences. However, the variation in inflation is of both low- and high-frequency whereas the variation in the age shares is low-frequent. Differencing low-frequency variables would likely cause any relationship to vanish. Indeed, experimenting with age models in differences explained practically nothing. Regarding the unit root findings on the age shares, one may argue that in the long-run they should all be stationary when the transition has run its course. The possible non-stationarity properties of the demographic variables are therefore not necessarily of unit root type. Moreover, traditional unit root tests have low power in the presence of structural changes. The shift in monetary policy in 1992 is a textbook example of a structural change that may cause detection of spurious unit roots in the inflation rates series.[5] In the balance between estimating in levels or differences the first alternative is therefore preferred for the age models.

3.3 Estimation

The models in Table 1, estimated by least squares, are named LS I, LS II, LS III and LS IV respectively. The autoregressive models that will be used as benchmarks are named AR(1) I and AR(1) II. These models are all special cases on the general form (3.1).

$$\pi_t = \alpha + \sum_{i=1} \phi_i \pi_{t-i} + \sum_{a=15-24}^{75+} \beta_a S_{a,t-12} + \sum_j \gamma_j D_j + \varepsilon_t \qquad (3.1)$$

In (3.1) π_t is inflation, S_a is the a:th age share and D_j is the j:th dummy-variable. In Table 1 the estimated coefficients from an ARIMA model are also presented.[6] Successive elimination of insignificant autoregressive terms yielded the LS IV specification. Regressions using solely the age shares (and dummy variables) when explaining the course of inflation are also included in

[4] Experimenting with linear interpolation the unit root null hypothesis was rejected for three age shares.

[5] The change to a floating exchange rate and a low inflation standard as the guideline for the monetary policy in 1992 ended the full employment standard as the primary goal of Swedish stabilization policy. The full employment standard (1973 - 1992) at the expence of price stabilization resulted in several devaluations, the devaluation in 1982 being the most aggressive.

Given a structural change the unit root test statistic is biased towards non-rejection of the unit root null.

[6] The ARIMA specification is $\Delta\pi_t = \alpha + \phi_{12}\Delta\pi_{t-12} + \phi_{24}\Delta\pi_{t-24} + \varepsilon_t.$

Table 1. By estimating LS I and LS II it will be possible to compare the relative age e¤ects with the more elaborate LS IV and age-GARCH (presented in Table 2). Moreover, since unit root testing indicated that both in‡ation and the age shares may be I(1) processes, LS I and LS II will be utilized when testing for a cointegrating relationship, see the next section.

From a life-cycle viewpoint we expect that economically active should dampen in‡ation whereas economically passive should in‡ict the opposite relation. Since the age shares can only be interpreted relative to each other, the results in Table 1 are reasonably well in line with what may be expected within a life-cycle framework. Similar results has been found in studies on yearly data indicating that the frequency is of minor importance, see e.g. Lindh (1999). The large negative e¤ect that elderly has on in‡ation is unexpected from a life-cycle point of view. However, the …nding that elderly do not consume as much as the life-cycle hypothesis predicts is relatively common in the empirical literature. Precautionary savings or bequest motives are two plausible explanations for this pattern, see Bernheim (1987) or Hurd (1990) for an extensive discussion on this subject.

The …t using solely the age shares as regressors is surprisingly good. Incorporating dummy-variables for the devaluation in 1982 and the shift to the ‡oating exchange rate regime in 1992 do not alter the parameter estimates signi…cantly.[7] Since no short run variation is picked up in LS I and LS II, it is not surprising that the residuals are serially correlated and ARCH-e¤ects are present. In the preferred autoregressive distributed lag (ADL) model, LS IV, the test statistics are more promising. The exception is the JB statistic that rejects the null of normally distributed residuals. In fact, the JB statistic rejects normality in all but the LS II speci…cation. When we studied the residuals more closely it was evident that including autoregressive terms have resulted in more outliers why normality was rejected for these speci…cations. In this aspect, LS II seems to be a reasonable rough approximation of the in‡ation path.

When autoregressive terms are incorporated, the absolute magnitudes of the age coe¢cients decrease, but the relative age e¤ects are qualitatively similar. The Wald statistic strongly indicates that the age shares jointly contribute to the model. We conclude that demography matters when explaining

[7] The 1982 devaluation dummy takes the value one for the period 1980:1 - 1981:11 and the 1992 in‡ation targeting dummy takes the value one for the period 1990:1 - 1991:12. Empirically, the main part of the structural shift occurred before the actual policy implementations.

The in‡ation targeting regime 1993 and onwards has often been modelled by a dummy-variable that takes the value one for the entire period. We will discuss this alternative speci…cation shortly.

the course of inflation.

Table 1. Dependent variables are π_t and $\Delta(\pi_t)$.

	LS I	LS II	LS III	LS IV	ARIMA
α	-1.274^b	-1.217^a	0.001^b	-0.273^a	-0.000
	[0.019]	[0.010]	[0.023]	[0.009]	[0.702]
π_{t-1}			1.021^a	0.924^a	
			[0.000]	[0.000]	
π_{t-12}^{*}			-0.514^a	-0.491^a	-0.617^a
			[0.000]	[0.000]	[0.000]
π_{t-13}			0.469^a	0.399^a	
			[0.000]	[0.000]	
π_{t-24}^{*}					-0.342^a
					[0.000]
S_{15-24}	-0.021	0.031		0.014	
	[0.963]	[0.935]		[0.868]	
S_{25-49}	1.949^b	1.592^c		0.379^b	
	[0.030]	[0.057]		[0.021]	
S_{50-64}	1.794^b	2.049^a		0.491^a	
	[0.049]	[0.006]		[0.005]	
S_{65-74}	5.489^a	5.331^a		0.976^a	
	[0.000]	[0.000]		[0.000]	
S_{75+}	-2.061^a	-1.729^a		-0.347^a	
	[0.000]	[0.000]		[0.000]	
D_{1982}		0.038^a	0.002^c	0.005^a	
		[0.000]	[0.086]	[0.002]	
D_{1992}		0.053^a	0.002	0.010^a	
		[0.000]	[0.211]	[0.000]	
$\overline{R}^2$	0.674	0.810	0.969	0.971	0.303
DW	0.125	0.230			
χ^2 (5)	358 [0.000]	523 [0.000]		46.6[0.000]	
Q(1)	417.9^a	363.3^a	0.791	0.214	1.369
Q(5)	1546^a	1160.4^a	5.367	4.074	5.122
Q(10)	2087^a	1438.5^a	21.12^b	22.50^b	33.988^a
ARCH-LM[10]	344 [0.000]	312 [0.000]	8.71[0.602]	5.64[0.844]	7.05[0.721]
JB	14.8[0.000]	0.73[0.963]	189 [0.000]	125 [0.000]	299 [0.000]

Notes: Newey-West corrected standard errors. p-values in [brackets]. ^{a}, ^{b} and ^{c} indicate significance at the 1% , 5% and 10 % level, respectively. χ^2 is a Wald test for the joint significance of the age shares. * indicates that the variable is first differenced. Q(k) tests the null hypothesis of no autocorrelation up to order k. JB tests the null hypothesis of normally distributed residuals. Sample (adjusted) is 1961:1 - 2000:8.

The di¤erence between LS III and LS IV is the inclusion of the …ve age shares in the latter speci…cation. Therefore, these speci…cations o¤er an interesting comparison since the net-e¤ect from using the age shares as regressors is illustrated. At …rst glance the inclusion of the …ve age shares does not seem to improve the in-sample …t signi…cantly. $\overline{R}^2$ is only marginally improved. However, out-of-sample the inclusion of the age shares will drastically improve the forecasting accuracy. The regime dummies in LS III are insigni…cant at conventional levels. But since the forecasts from this speci…cation were better than forecasts from a more parsimonious speci…cation without these dummy variables, the LS III speci…cation was chosen as one of the benchmarks. Further, it is interesting, though not readily explainable, that the regime shifts are more signi…cantly picked up when the age variables are included.

Multicollinearity may result in imprecise regression coe¢cients since the standard errors would be large in relation to these coe¢cients. But most parameter estimates are statistically signi…cant, indicating that multicollinearity has been reduced to an acceptable level. This conclusion was strengthened when bootstrapping the standard errors. The con…dence intervals were only marginally altered when bootstrapping.[8]

4 Speci…cation tests

The results thus far indicate that demography in‡uences the course of in‡ation. This conclusion is unwarranted if the age shares are proxies for other economic forces at work, as pointed out by MacMillan & Baesel (1990). In this section we will therefore consider the robustness of the results. Omitted variable bias and spurious regression will be investigated. Moreover, it will be considered whether the relationship between demography and in‡ation has changed due to the explicit in‡ation targeting after 1992.

4.1 Omitted variable bias

In order to check for omitted variable bias in LS IV a set of other macroeconomic variables will be included. Since these variables probably are determined simultaneously with the in‡ation rate, least squares will not yield consistent parameter estimates. The two-stage-least square (2SLS) method was instead applied.

[8] These regressions are available on request.

Table 2. Dependent variable is ¼$_t$:

	AR(1) I	AR(1) II	age-GARCH	2SLS
C	0.001^b [0.033]	0.003^a [0.005]	-0.284^a[0.004]	-0.231^a[0.066]
¼$_{t ¡ 1}$	0.980^a [0.000]	0.960^a [0.000]	0.919^a [0.000]	0.851^a [0.000]
¼$_{t ¡ 12}$			-0.488^a[0.000]	-0.126^a[0.000]
¼$_{t ¡ 13}$			0.307^a [0.000]	
$S_{15 ¡ 24}$			0.012 [0.878]	-0.199^c[0.057]
$S_{25 ¡ 49}$			0.401^a [0.010]	0.331^a [0.100]
$S_{50 ¡ 64}$			0.519^a [0.010]	0.533^b [0.019]
$S_{65 ¡ 74}$			0.989^a [0.000]	1.114^a [0.000]
S_{75+}			-0.368^a[0.000]	-0.566^a[0.000]
D_{1982}		0.003 [0.204]	0.005^a [0.010]	0.004^b [0.034]
D_{1992}			0.012^a [0.001]	0.012^a [0.000]
D_{1992f}		-0.002^b[0.027]		
i_t				0.057^b [0.013]
b_t				0.000 [0.294]
TIP_t				-0.003 [0.830]
$\overline{R}^2$	0.960	0.960	0.971	0.964
Â^2 (5)			35.52 [0.000]	30.36 [0.000]
Q(5)	5.464	5.548	7.396	6.539
Q(10)	30.05^a	29.79^a	20.669^a	35.87^a
ARCH-LM(10)	6.861 [0.738]	5.791 [0.832]	5.819 [0.830]	5.971 [0.817]
¾^2 equation				
C			0.000 [0.776]	
ARCH			0.063^a [0.000]	
GARCH			0.933^a [0.000]	

Notes: Bollerslev-Wooldrige robust standard errors and covariances in age-GARCH. Newey-West corrected standard errors in 2SLS. p-values in [brackets]. ^{a}, ^{b} and ^{c} indicate signi…cance at the 1% , 5% and 10 % level, respectively. Â^2 is a Wald test for the joint signi…cance of the age shares. ARCH-LM(q) tests the null hypothesis of no ARCH-e¤ects up to order q. Sample (adjusted) are 1962:4 - 2000:8 for age-GARCH and 1962:4 - 1999:10 for 2SLS.

In 2SLS, see Table 2, the age shares and the lagged dependent variables serve as their own instruments whereas the control variables were instrumented by one lag of each variable. All age shares are signi…cant at the ten per cent level. Experimenting with more elaborate 2SLS regressions produced estimates of the age shares similar to those reported in Table 2.[9] An equivalent test for omitted variables can be based on the LS IV residuals. If

[9] In 2SLS i_t is the 3 month treasury bill rate, b_t is the 5 year government bond rate and TIP_t is total industrial production. 2SLS regressions including money supply, real TCW-

some relevant variables are omitted an explainable pattern in the residuals should be found, see Table A.2 for the results. Practically no variation in the residuals was explained. We conclude that the demographic variables should not be interpreted as proxies for omitted economic factors in the LS regressions.

Since Milton Friedman's Nobel lecture the relationship between inflation uncertainty and the inflation rate has attracted considerable interest in the literature. High rates of inflation may create more uncertainty about future inflation. From Figure 2 it is evident that high inflation rates have resulted in more variable inflation rates. Therefore it is plausible that a time-varying conditional variance should be incorporated when modelling the inflation process. The conditional variance is modelled by a GARCH(1,1) and the specification is based on the preferred ADL (i.e. LS IV). The model, hereafter referred to as age-GARCH, is presented in Table 2. In the out-of-sample exercise we will see whether modelling the conditional variance will improve inflation forecasts. In Table 2, two of the benchmark models, AR(1) I and AR(1) II, are also presented. These models will be discussed in the forecasting exercise.

4.2 Spurious regression

The age models were all estimated in levels. The relative age-effects appear to be robust across specifications and fairly in line with what we would expect from theory, not indicating a spurious relation. However, if the estimated relation is in fact spurious, the residual series will have a unit root. When testing, the null hypothesis was consistently strongly rejected, indicating stationary residual series for all age models. If the time-series in fact are I(1) but also cointegrated, this would explain why the results in Table 1 and Table 2 are reliable. Estimating in levels would then not inflict a spurious relationship but instead super consistent parameter estimates.[10] This was investigated by estimating error-correction models (ECMs). The ECMs have the general form as in equation (3.2). The results are presented in Table 3.

index, government financial savings, the index of leading indicators and the current account balance were also estimated. The relative age-effects remained throughout. Available on request.

[10] The LS estimator is super consistent if its asymptotic variance is $O\left(1/T^2\right)$ rather than $O(1/T)$, see e.g. Davidson & McKinnon (1993).

$$\Delta(\pi_t) = \alpha + \gamma\left[\pi_t - \sum_{a=15-24}^{75+} \beta_a S_{a;t-12} - \sum_j \lambda_j D_j\right] + \sum_{j=1} \psi_j \Delta(z_{j;t-12}) + \varepsilon_t \tag{3.2}$$

In (3.2) S_a is the a:th age share and z_j is the j:th predetermined variable. The dynamic behavior can be explained in terms of long- and short-run equilibrium relationships. In (3.2) the long-run relationship is assumed to be given by the age shares. Note that the expression inside brackets (under the restriction that $\lambda_j = 0; \forall_j$) corresponds to the LS I model in Table 1. The deviation from the long-run equilibrium, i.e. the short-run variation, is represented by the set of differences of the variables in Z, including e.g. inflation and interest rates. In this framework, estimating LS I would correspond to the first step of the Engle-Granger (1987) two-step cointegration procedure. In LS I the very low DW statistic and the Q-statistics indicate that the residuals are not white noise. This is expected since no short run variation is intercepted. The unit root null hypothesis was strongly rejected for the residuals of LS I (and LS II) indicating stationarity. Hence, the general ECM specification in (3.2) could probably be accepted. In Table 3 the two oldest age groups are significant at the one per cent level whereas the other age shares are not. The relative age effects are similar to those previously estimated and the error correction coefficient, γ, is highly significant. Turning to the other variables, $\Delta(\pi_{t-12})$ is also highly significant indicating that a lot of the short-run variation is absorbed by this variable. None of the other variables in differences are significant on the five per cent level but some are at the ten per cent level. We take this as further evidence against the possibility of spurious parameter estimates.

The new monetary regime in 1992 may have altered the inflation process. Therefore it is interesting to investigate whether the relationship between demography and inflation also has changed since the explicit inflation target was adopted. To do so, a set of variables on the form $D_{regime} \sum_{a=15-24}^{75+} b_a S_{a;t-12}$ was augmented to the preferred ADL specification. The dummy variable (D_{regime}) is set to be one for 1993:1 - 2000:8 and zero otherwise. The estimated model is presented in Table A.4. All dummy-augmented age shares are insignificant at conventional levels, indicating that the demography/inflation relationship has not significantly changed due to explicit inflation targeting. The Wald statistic (χ^{2*}) rejects the null of jointly significant dummy-augmented age shares. It should be emphasized that this is a decisive argument for using the age model for forecasting purposes. If the relationship had changed the arguments in favour of using demography for forecasting purposes would have weakened considerably.

Table 3. The error-correction models. Dependent variable is $¢¼_t$:[11]

	ECM I	ECM II
®	0.076 [0.388]	0.110 [0.235]
°	0.083^a [0.000]	0.087^a [0.000]
$S_{15 ¡ 24}$	-0.315 [0.734]	-0.052 [0.954]
$S_{25 ¡ 49}$	1.586 [0.335]	2.000 [0.215]
$S_{50 ¡ 64}$	0.993 [0.564]	1.716 [0.336]
$S_{65 ¡ 74}$	5.076^a [0.000]	5.514^a [0.000]
S_{75+}	-2.332^a[0.002]	-2.165^a[0.005]
$¢(¼_{t ¡ 12})$	-0.496^a[0.000]	-0.507^a[0.000]
$¢(i_{t ¡ 12})$	0.038 [0.194]	0.047 [0.112]
$¢(b_{t ¡ 1})$		0.170^c [0.097]
$¢(CAB_{t ¡ 1})$		-0.290^c[0.081]
$¢(GFS_{t ¡ 1})$		0.109 [0.211]
$¢(\ln TCW_{t ¡ 1})$		0.029 [0.103]
$¢(TIP_{t ¡ 1})$		0.015^c [0.062]
$\overline{R}^2$	0.264	0.298
Q(1)	0.033	0.048
Q(5)	5.728	3.247
Q(10)	26.01^a	19.16^b
$Â^2$	115.8^a [0.000]	99.14^a [0.000]
ARCH-LM(10)	10.72 [0.380]	6.097 [0.807]

Notes: Newey-West corrected standard errors. p-values in [brackets]. ^{a}, ^{b} and ^{c} indicate signi…cance at the 1% , 5% and 10 % level, respectively. Q(k) is the Ljung-Box statistic of no residual autocorrelation up to order k. ARCH-LM indicates no heteroscedasticity in the residuals on conventional signi…cance levels. $Â^2$ is a Wald test for the joint signi…cance of the age shares. Samples (adjusted) are 1962:4 - 2000:8 for ECM I and 1962:4 - 1999:11 for ECM II.

Finally, when estimating recursively, which is shown in Figure A.1, this conclusion was strengthened. For the post 1992 period all parameter estimates are very stable. In fact, they seem to settle down and stabilize during the post 1992 period.[12]

[11] i_t is the short interest rate, b_t is the long interest rate, CAB_t is the current account balance, GFS_t is government …nancial savings, $\ln(TCW)_t$ is the log of the TCW index, TIP_t is total industrial production.

[12] When computing the recursive estimates, the new exchange rate regime dummy was excluded. Including the variable would add further stability to the system.

4.3 System estimation

In section two it was argued that demography may have affected inflation via productivity and, in turn, y^*. If so, people in the age brackets 25 - 49 and 50 - 64 should affect productivity and y^* positively, whereas the other age groups should inflict the reverse effect. People in their working years are therefore expected to affect $y - y^*$ negatively. Alternatively, according to the life-cycle hypothesis, changes in the demographic pattern should affect actual output, y, rather than y^*: People in their working years should boost savings, reduce consumption and cause y to fall, also affecting $y - y^*$ negatively. In order to show that the economic forces at work are consistent with these lines of reasoning a traditional Phillips-Okun relation, augmented with the age shares, was estimated (see Table A.2). Since π and $y - y^*$ in (2.3) are collinear with the age shares and not mutually independent one should expect the estimated coefficients to exhibit some interaction, as pointed out by Lindh (1999). It is also very conceivable that the residuals in the system are contemporaneously correlated. Estimating the system by the seemingly unrelated regression model, SUR, efficiency should therefore be improved.

Studying Table A.2 we see that the results are consistent with the discussion in section two. People in their working years are affecting $y - y^*$ negatively, whereas senior citizens inflict the reverse relationship. It is also evident that the prime aged are affecting $y - y^*$ the most by large. Studying Figure 1 we see that the prime aged peaked around 1990. It is therefore conceivable that not recognizing the impact of demography on $y - y^*$ may have resulted in underestimating the latter. This view has recently been expressed by the Riksbank, see the Inflation Report (2000:3).

When forecasting inflation we will not include $y - y^*$ even though the variable enters significantly in the inflation equation. Since one would need projections of $y - y^*$, excess uncertainty would be introduced, probably resulting in poorer inflation forecasts. The output gap, retrieved from a quarterly Hodrick-Prescott filtered GDP series, is also hard to predict, not least since GDP is revised and not actually available at time t: Further, the $\overline{R}^2$ in the output gap equation is rather low, indicating that more explanatory variables need to be included.

5 Forecasting

The rest of the paper will be devoted to the inflation forecasts and evaluations thereof. The analysis thus far has indicated promising qualities of the LS IV specification. Hence the focus will be on evaluating this specification out-of-sample. However, considering the possibility of time-varying conditional variability in the in‡ation series, the age-GARCH will also be investigated. We argue that the out-of-sample exercise will judge whether the evolving age-structure incidentally happened to correlate with in‡ation in-sample, or if the estimated models can be interpreted as reasonable approximations of the true course of in‡ation.

5.1 Forecasting Swedish in‡ation

Since the projection errors of the age shares …ve to ten years into the future will be relatively minor we would expect forecasts based on the age models to perform well on this horizon. From the viewpoint of the Riksbank, these long run forecasts would probably not be as interesting as forecasts on shorter horizons. Therefore, the focus will be on evaluating forecasts on the one- to …ve-year horizons. Forecasts on the one- and two-year horizons are likely to be the most interesting, considering that policy actions to curb in‡ation are believed to take e¤ect with a lag of this magnitude.

In the out-of-sample exercises, forecasts are made using only data available to the forecaster.[13] The setup of the exercise is the following. The di¤erent models are …rst estimated using actual data up to 1995:5, leaving 63 in‡ation observations for evaluating forecasting accuracy. In the …rst step, the LS IV results were used making forecasts 5 years (i.e. 60 periods) ahead. In the next two steps the in-sample period was extended by one and by two periods respectively, yielding a total of three …ve-year forecasts. Next, following the same iterative procedure, we make 15 four-year forecasts, and so forth for three- two- and one-year horizons. This iterative procedure is then repeated for the other models. Varying the forecasting horizon the forecasting performance both in the short- and in the medium-run is evaluated. By repeating the forecasts on any given horizon we get the multiple observations which should improve stability.

Before continuing it may be interesting to study some of the forecasts graphically. In Figure 3 a sample of forecasts on various horizons is presented.[14] The LS IV seem to follow the in‡ation trends well. That cannot be said about the autoregressive models, AR(1) I and AR(1) II. The ARIMA

[13] Note that the cpi unlike GDP is not revised, thus data were actually available at time t. For the age shares the 1999 projections were used, but the impact is negligible.

[14] The sample of nine forecasts that are graphically presented are the same for all models. The sample has been randomly selected.

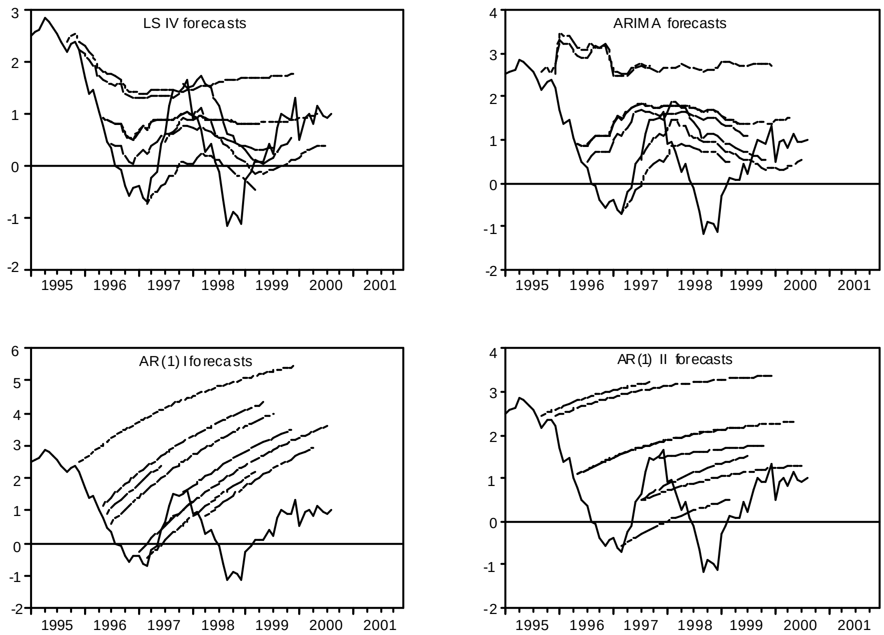

Figure 3: Selection of out-of-sample forecasts on the two- to four-year horizons. LS IV is up to the left, ARIMA is up to the right, AR(1) I is down to the left and AR(1) II is down to the right. The scale on the y-axis is per cent.

forecasts appear to be rather accurate but when comparing with the LS IV forecasts the latter is probably superior. However, in order to properly evaluate the forecasts various well-known statistics will be employed.

Note that beside the empirically estimated models the results for the 2 per cent forecast are presented in Table 4. The 2 per cent forecast corresponds to the stipulated in‡ation target and should therefore be optimal ex post the monetary policy.

In Table 4 (as well as in Table 5) the mean error (ME), the mean absolute error (MAE), the root mean square error (RMSE), the Theil's U and the Theil's inequality coe¢cient are presented. If ME and MAE are equal (and positive) this indicates that the model systematically overpredicts. RMSE penalizes large errors relatively more than MAE. Unless the errors are of equal size, RMSE will exceed MAE (and ME). A comparison with a model that is optimal under a random walk process is provided by Theil's U. A Theil's U smaller than unity should be interpreted as that the given model outperforms the random walk forecast. Finally, Theil's inequality coe¢cient always lies between zero and one, where zero indicates a perfect …t. Theil's inequality coe¢cient essentially normalizes the RMSE statistics.

Table 4. Out-of-sample forecasting evaluation for LS III and the benchmark models.

	# obs	horizon	ME	MAE	RMSE	Theil's U	Theil's IC
	3	5 years	0.0169	0.0169	0.0169	1.08	0.47
	15	4 years	0.0057[8]	0.0079[8]	0.0098[8]	0.69[8]	0.40[8]
LS IV	27	3 years	0.0038[8]	0.0138[8]	0.0161[8]	0.47[8]	0.85
	39	2 years	0.0002[8]	0.0058[8]	0.0067[8]	0.45[8]	0.39[8]
	51	1 year	0.0019[8]	0.0092[8]	0.0108[8]	0.58[8]	0.68
	3	5 years	0.0458	0.0458	0.0458	2.93	0.70
	15	4 years	0.0430	0.0430	0.0433	3.43	0.71
LS III	27	3 years	0.0411	0.0411	0.0429	1.42	0.82
	39	2 years	0.0316	0.0316	0.0328	2.56	0.71
	51	1 year	0.0251	0.0251	0.0285	1.51	0.76
	3	5 years	0.0104[8]	0.0104[8]	0.0104[8]	0.66[8]	0.35[8]
	15	4 years	0.0114	0.0114	0.0118	1.60	0.42
2 per cent	27	3 years	0.0171	0.0171	0.0186	0.92	0.99
	39	2 years	0.0150	0.0156	0.0167	1.94	0.54
	51	1 year	0.0167	0.0167	0.0183	1.29	0.65[8]
	3	5 years	0.0463	0.0463	0.0463	2.96	0.71
	15	4 years	0.0440	0.0440	0.0442	6.14	0.72
AR(1) I	27	3 years	0.0427	0.0427	0.0444	2.83	0.82
	39	2 years	0.0315	0.0315	0.0323	3.28	0.70
	51	1 year	0.0216	0.0217	0.0260	1.32	0.76
	3	5 years	0.0188	0.0188	0.0188	1.21	0.49
	15	4 years	0.0132	0.0132	0.0155	1.13	0.49
ARIMA	27	3 years	0.0103	0.0154	0.0198	0.56	0.80[8]
	39	2 years	0.0067	0.0111	0.0129	1.17	0.54
	51	1 year	0.0075	0.0136	0.0170	0.87	0.73

Notes: Statistic followed by [8] if best across speci…cations on the stated horizon.

According to the statistics presented in Table 4 the speci…cations using age shares as regressors are superior to the alternatives on the one to four year horizon. The forecasting errors of the benchmark models are in many instances three times the forecasting errors of the age model. Comparing the benchmarks we see that the ARIMA performs considerably better than the purely autoregressive models, AR(1) I and LS III. The age model outperforms the ARIMA almost throughout. Further, comparing ME and MAE across speci…cations and horizons it is clear-cut that the age model systematically overpredict the least. The age model is particularly accurate on the two-year horizon. Since this probably is the horizon that the Riksbank cares the most about, the result is interesting.

One may argue that the target in‡ation rate should be the best forecast on every horizon if the Riksbank has access to reliable forecasts and conducts monetary policy accordingly. It can be seen from Table 4 that the 2 per cent forecast is best at the …ve-year horizon. The 2 per cent forecast is also better than the ARIMA forecasts on the …ve- and four-year horizons and it outperforms the AR(1) I on all horizons. The age model outperforms the 2 per cent forecast on all but the …ve-year horizon. Furthermore, the di¤erences on the longest horizon are relatively minor. One should note that the number of observations is small at the …ve-year horizon, perhaps preventing us form correctly ranking the speci…cations.

Remember that the di¤erence between LS III and LS IV is the inclusion of the …ve age shares in the latter speci…cation. Comparing the two models out-of-sample, it is evident that inclusion of demographic variables signi…cantly improves forecasting ability. This may be expected on the longer horizons, but the major di¤erences on the one- and two-year horizons are more surprising. Overall, the evidence that age-structure has signi…cant forecasting power on in‡ation seem clear-cut. Consequently, the concern of a spurious relationship is increasingly unlikely. The strong out-of-sample forecasting performance of LS IV could hardly have been accomplished by chance.

One could argue that benchmark models are misspeci…ed and forecast poor accordingly. Since the demographic pro…le obviously in‡uences the course of in‡ation this is true. However, we feel that presenting various well-known alternatives is relevant. Without the benchmarks we would not be able to say how good the age forecasts actually are. In-sample, it was shown that interest rates and the output gap a¤ect in‡ation. It is not necessary that a larger econometric model including these and/or other variables would forecast better than the forecasts presented here. For sake of completeness we will evaluate the forecasts of a very elaborate model in a moment.

Studying Figure 4 it is clear that LS III and AR(1) I systematically over-predicts. The probable reason may be that these models do not adequately catch the new low-in‡ation environment in the forecasting period. Introducing a new in‡ation-targeting dummy-variable that takes the value one for 1993 and onwards could improve upon these forecasts. Another benchmark model, AR(1) II, was therefore estimated, see Table A.5 for the in-sample results. A similar modi…cation of the age-model did not improve upon the out-of-sample statistics, indicating that the age structure probably has supported the implementation of in‡ation targeting. However, modelling of the conditional variance as in age-GARCH did generate some interesting out-of-sample results, reported in Table 5. In Table 5 we also evaluate AR(1) II, and the consensus forecasts. The latter is only presented at the one-year horizon due to lack of observations on the longer time-spans.

Table 5. Out-of-sample forecasting evaluation for age-GARCH, consensus and AR(1) II.

	# obs	horizon	ME	MAE	RMSE	Theil's U	Theil's IC
Consensus	5	1 year	0.0111	0.0111	0.0116	1.74	0.31
age-GARCH	3	5 years	0.0161	0.0161	0.0161	1.03	0.45
	15	4 years	0.0049	0.0075	0.0092	0.66	0.38
	27	3 years	0.0026	0.0142	0.0163	0.53	0.87
	39	2 years	-0.0005	0.0061	0.0068	0.52	0.41
	51	1 year	0.0012	0.0095	0.0108	0.65	0.70
AR(1) II	3	5 years	0.0285	0.0285	0.0285	1.82	0.60
	15	4 years	0.0205	0.0205	0.0221	1.61	0.57
	27	3 years	0.0172	0.0180	0.0243	0.50	0.79
	39	2 years	0.0119	0.0121	0.0144	1.52	0.51
	51	1 year	0.0079	0.0142	0.0175	0.64	0.76

Notes: The consensus forecasts are forecasts of Swedish inflation made by professional forecasters from the business and financial community. The age-GARCH and the AR(1) II are presented in Table A.2.

Comparing the results in Table 4 and Table 5 it is clear that LS IV outperform the AR(1) II on all horizons. Moreover, both age models, LS IV and age-GARCH, perform better than the consensus forecasts which systematically overpredicts. If demography has influenced y^* in accordance with the above discussion, this may be the reason for the poor forecasting performance of the consensus forecasts. The relatively large proportions of prime aged and middle aged in the 1990s have probably affected $y - y^*$ negatively: We argue that it is unlikely that the consensus forecasters have taken these country-specific demographic characteristics into account since the Riksbank only recently has paid attention to it. If so, it is not surprising that the consensus forecasts overpredict inflation, e.g. via the Phillips-Okun relationship. Since Swedish inflation has been below the lower bound of the tolerance interval (i.e. below 1 per cent) for a significant part of the post 1995 period, one may argue that the same applies for the Riksbank. Not recognizing that a relatively large proportion of people in their working years would counteract inflationary tendencies, inflation forecasts would overshoot. Monetary policy based on these forecasts would be too restrictive and actual inflation rates would fall below the target.

Comparing LS IV and age-GARCH we see only marginal differences on all horizons, judging from ME, MAE and RMSE. Modelling the conditional variance seems therefore not to improve the forecasting ability significantly. Since the formal test in the preferred ADL model did not indicate ARCH

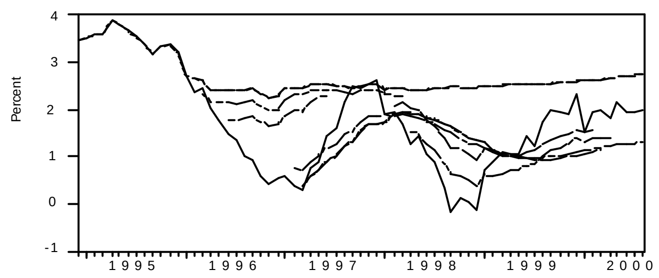

Figure 4: Selection of out-of-sample forecasts on various horizons based on age-GARCH.

e¤ects, this result was rather expected. A sample of age-GARCH forecasts is presented in Figure 4.

5.2 The age model versus a multivariate VAR

The benchmark models have all been speci…c and parsimonious in design. An interesting extension is therefore to study how well the preferred age model keeps up with the opposite; i.e. a general multivariate vector autoregressive (VAR) model with long-run equilibrium restrictions. The model, hereafter foa-VAR, has been used by the Riksbank, why it is fair to say that the competing model is the best currently available.[15] The results are presented in Table 6.

In Table 6 the LS IV reports the results for the whole forecasting sample whereas the results in LS IV¤ correspond to the same observations that are available for the Foa-VAR. The results indicate that foa-VAR has generated very accurate forecasts, especially on the one-year horizon. Comparing the Foa-VAR forecasts with the corresponding forecasts generated by the age model, we see that the foa-VAR model performs better. When comparing with the age model estimated on the whole forecasting sample we see that the di¤erences are minor. Judging by the RMSE the foa-VAR is better, but according to the Theil's U the age model is the most accurate.

One caveat is that the forecasts from the foa-VAR only were available for the period 1999:6 - 2000:9. This short period is not particularly representative since actual in‡ation was relatively high. Moreover, the scarce number of observations available for the foa-VAR model makes it hard to draw any

[15] See Jacobson, T. et al.(1999), the Riksbank Working paper series no 77, available at www.riksbank.se.

strong conclusions. However, the results do not contradict the previous results. The relatively simple age model seem to be a strong tool for forecasting Swedish in‡ation. It is remarkable that the parsimonious age model keeps up with the elaborate foa-VAR.

Table 6. Out-of-sample forecasting evaluation for the foa-VAR and LS IV.

	# obs	horizon	ME	MAE	RMSE	Theil's U
Foa-VAR	5	1 year	0.0006^8	0.0066^8	0.0073^8	1.44
	3	2 years	0.0034	0.0039^8	0.0047^8	0.52
LS IV	51	1 year	0.0019	0.0092	0.0108	0.58^8
	39	2 years	0.0002^8	0.0058	0.0067	0.45^8
LS IV¤	5	1 year	-0.0089	0.0089	0.0097	1.27
	3	2 years	-0.0127	0.0127	0.0136	1.08

Notes: Statistic followed by ^{8} if best across speci…cations on the stated horizon.

5.3 Extending the forecasting horizon

Studying Figure 1 a picture of an aging population emerges. A relatively more dependent population is associated with more public consumption and less tax-revenues than a younger, more productive age-pro…le. Therefore will savings be reduced in …ve to ten years when the big 1940s cohort enters retirement. The conceivable decrease in average labor productivity as well as the increase in government consumption may therefore in‡ict a strong in‡ationary tendency on the economy. The changes in aggregate savings may in turn have serious implications for a wide range of macroeconomic variables, which could a¤ect in‡ation indirectly.

In Figure 5 (left) we have graphed the actual and the predicted values of in‡ation based on LS IV speci…cation up to year 2020. The age model predicts that the demographic structure will have an in‡ationary e¤ect on in‡ation over the coming 17 years, peaking 2017:7 with 16.6 per cent annualized in‡ation. Then the de‡ationary tendencies will dominate for the rest of the forecasting period. In the last period, 2019:12, the predicted in‡ation rate is 11.3 per cent. The pattern in Figure 5 is an e¤ect of the big baby boom cohort of the 1940s, marching through the two …nal phases. Remember from Table 1 that newly retired was the most in‡ationary group whereas elderly on the other hand was the most de‡ationary group. These characteristics explain why it will take until a majority has passed on to the oldest phase until the de‡ationary tendencies dominates. In Figure 5 (right) the long-run forecasts generated from the three estimated benchmark models are presented.

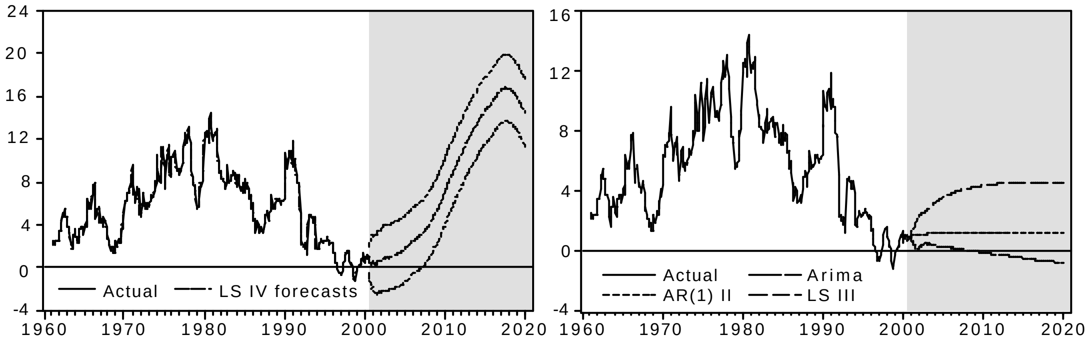

Figure 5: Left: actual in‡ation (solid), predicted (dashed) and con…dence intervals (dashed). Forecasts 2000:8 - 2019:12 based on LS IV. Right: actual in‡ation (solid) and predicted (dashed). Forecasts 2000:8 - 2019:12 based on AR(1) II, ARIMA and LS III. The scale on the y-axis is per cent.

It is worth emphasizing that in‡ation is a policy variable. Given that Sweden applies a similar in‡ation-targeting in the future the forecasts generated from AR(1) II are the most probable. In Figure 5 (right) we see that these forecasts level out at the two per cent level. The long-run forecasts generated by LS IV will not be realized under in‡ation-targeting. Instead, these forecasts may be interpreted as the expected age-in‡icted in‡ationary pressure in the years to come.

6 Concluding remarks

The impact of demography on in‡ation has been investigated in this paper. The results strongly indicate that demography in‡uences the course of in‡ation. Other explanatory variables did not change the relative age e¤ects. The expected pattern, i.e. that people in their working years have in‡icted de‡ationary tendencies whereas dependent people have in‡ationary e¤ects, is found in all age-model speci…cations. The only result that was surprising form a stylized life-cycle viewpoint is that elderly was the most de‡ationary group. It has also been emphasized that demography could in‡uence in‡ation via the supply side of the economy. The traditional Phillips curve may therefore help explaining the economic forces at work. But to fully explore the channels via which demography is a¤ecting in‡ation (as well as other macroeconomic variables) further research is needed.

The age models perform surprisingly well out-of-sample. The LS IV and age-GARCH outperform the estimated benchmark models on all forecasting horizons. Moreover, the age models outperform the stipulated, 2 per cent forecasts on all but the five-year horizon as well as the consensus forecasts. Since the age models were so accurate, particularly on the two-year horizon, we conclude that demography contains information that should not be overseen when forecasting inflation. By not recognizing the age effects systematical forecasting errors have been made. Hence, we argue that these results indicate that the Riksbank should incorporate demography in the policy analysis.

In the 1990s, Sweden has experienced an increasing fraction of people in their working years. The above discussion suggests that the demographic profile may have facilitated the implementation of the low-inflation-targeting policy. Moreover, the Riksbank has not recognized these age effects until relatively recently [Inflation Report (2000:3)]. By not taking demography into account, $y - y^*$ in (2.3) may have been wrongly estimated. If the Riksbank has conducted monetary policy accordingly, we would expect actual inflation to fall below the target since the policy probably would be too restrictive.

In the introduction it was argued that when forecasting inflation it is important to distinguish changes in the general direction of inflation from transitory fluctuations. Studying the sample of LS IV forecasts (see Figure 3) it is evident that the age-based forecasts follow the inflation trend well. Another interesting feature is that the forecasting errors in the age models do not increase much with the forecasting horizon.

In five years Sweden will experience a historically high proportion of dependents when the big 1940s cohorts enter retirement. In order to investigate how this will affect the inflation prospects a long-run forecasting exercise was conducted. The LS IV predicts that after 2005 there will be a sharp inflation trend increase with steadily increasing inflation rates up to 2017. Since Sweden has an explicit inflation target these very high inflation rates will not be realized. Instead, we may interpret the forecasts as an expected rise in inflationary pressure. Considering the strong performance of the age models on shorter forecasting horizons, we argue that these tendencies should be recognized by the Riksbank in order to be counteracted.

7 Appendix

Table A.1. Unit root tests and descriptive statistics.

	$S_{0 ¡ 14}$	$S_{15 ¡ 24}$	$S_{25 ¡ 49}$	$S_{50 ¡ 64}$	$S_{65 ¡ 74}$	S_{75+}	$¼_t$	$¢¼_t$
m	1	1	1	1	1	1	12	11
Mean	0.20	0.14	0.33	0.17	0.09	0.07	5.87	0.00
st.dev.	0.01	0.01	0.01	0.01	0.01	0.02	3.69	0.75
ADF^m	-1.08	-2.04	-0.88	-0.74	-1.69	-1.12	-1.85	-7.77^a
ADF^{12}	-0.84	-3.71^b	-1.90	-1.87	-1.59	-1.58	-1.85	-7.52^a
PP^5	-2.53	-1.96	-0.30	0.46	-2.36	-1.15	2.21	-21.8^a

Notes: m is the number of lags optimally selected by Schwartz Information Criterion. Superscript ^{a} and ^{b} indicate signi…cance at the 1 % and 5 % level respectively. The sample period is 1960:1 - 2000:8.

Table A.2. Dependent variables are $¼_t$ and $(y ¡ y^¤)_t$:

	$¼_t$	$(y ¡ y^¤)_t$
®	-0.541^a[0.009]	114.1^a [0.028]
$¼_{t ¡ 1}$	0.875^a [0.000]	
$¼_{t ¡ 12}$	-0.471^a[0.000]	-0.147^a[0.000]
$¼_{t ¡ 13}$	0.370^a [0.000]	
$(y ¡ y^¤)_t$	0.001^a [0.000]	
$(y ¡ y^¤)_{t ¡ 12}$		0.287^a [0.000]
$S_{15 ¡ 24}$	0.018 [0.863]	0.008 [0.772]
$S_{25 ¡ 49}$	1.033^b [0.014]	-3.652^a[0.000]
$S_{50 ¡ 64}$	0.859^a [0.006]	-1.247 [0.115]
$S_{65 ¡ 74}$	1.186^a [0.000]	1.551^a [0.001]
S_{75+}	-0.802^a[0.000]	2.232^a [0.000]
D_{1982}	0.006^a [0.000]	0.067 [0.845]
D_{1992}	0.010^a [0.000]	2.738^a [0.000]
$\overline{R}^2$	0.973	0.377
$Â^2$	51.22^a [0.000]	78.79^a [0.000]

Notes: Estimation method: iterative seemingly unrelated regression (Marquardt). p-values in [brackets]. ^{a}; ^{b} and ^{c} indicate signi…cance at the 1%, 5% and 10 % level, respectively. $Â^2$ is a Wald test for the joint signi…cance of the age shares. Sample (adjusted) is 1970:4 - 2000:8. The output gap was retrieved from a Hodrick-Prescott …ltered GDP series.

Table A.3. Dependent variable is the residuals from the LS IV specification.[16]

	LS IV residuals
α	-0.069 [0.311]
i_{t-1}	0.010 [0.694]
b_{t-1}	0.006 [0.870]
TIP_{t-1}	0.018 [0.083]
MS_{t-1}	$-4.3E^{-8}$ [0.791]
GD_{t-1}	$7.8E^{-9}$ [0.406]
LI_{t-1}	-0.000 [0.202]
NER_{t-1}	$3.5E^{-5}$ [0.537]
CAB_{t-1}	-0.060 [0.276]
GFS_{t-1}	-0.003 [0.770]
SRD_{t-1}	-0.000 [0.307]
LRD_{t-1}	-0.000 [0.136]
$\ln(TCW)_{t-1}$	0.009 [0.552]
GDP_{t-1}	0.012 [0.194]
USD/SEK_{t-1}	0.000 [0.370]
$\overline{R}^2$	0.029
DW	2.08
JB	95.67^a [0.000]
Q(1)	0.845 [0.358]
Q(5)	3.638 [0.767]
Q(10)	21.91^b [0.016]
BG-LM(6)	4.099 [0.663]
ARCH-LM(10)	5.499 [0.855]

Notes: Standard errors Newey-West corrected. p-values in [brackets]. ^{a}; ^{b} and ^{c} indicate significance at the 1%, 5% and 10 % level, respectively. DW is the Durbin-Watson test for first order serial correlation. BG-LM(q) is the Breusch-Godfrey test for serial correlation up to order q. ARCH-LM(q) tests the null hypothesis of no ARCH-effects up to order q. JB tests the null hypothesis of normally distributed residuals. Q(p) is the Ljung-Box test for serial correlation up to order p. Sample (adjusted) is 1962:3 - 1999:11.

[16] i_t is the three-month interest rate, b_t is the five-year interest rate, TIP_t is total industrial production, MS_t is the money supply, GD_t is government debt, LI_t is the index of leading indicators , NER_t is the nominal exchange rate, CAB_t is the current account balance, GFS_t is government financial savings, SRD_t is the short real interest rate differential, LRD_t is the long rea linterest rate differential, $\ln(TCW)_t$ is the log of the TCW index, GDP_t is the growth in GDP and USD/SEK_t is the US dollar/Swedish krona exchange rate.

Table A.4. The augmented LS IV (stability test equation).

®	-0.335[b] [0.032]
$S_{15 ¡ 24}$	0.301 [0.809]
$S_{25 ¡ 49}$	0.424[b] [0.048]
$S_{50 ¡ 64}$	0.709[b] [0.039]
$S_{65 ¡ 74}$	0.971[a] [0.007]
S_{75+}	-0.134 [0.686]
¼$_{t ¡ 1}$	0.919[a] [0.000]
¼$_{t ¡ 12}$	-0.486[a] [0.000]
¼$_{t ¡ 13}$	0.392[a] [0.000]
$D_{regime}S_{15 ¡ 24}$	1.428 [0.386]
$D_{regime}S_{25 ¡ 49}$	-0.129 [0.954]
$D_{regime}S_{50 ¡ 64}$	0.504 [0.528]
$D_{regime}S_{65 ¡ 74}$	-0.637 [0.910]
$D_{regime}S_{75+}$	-1.903 [0.351]
D_{1982}	0.005[a] [0.002]
D_{1992}	0.010[a] [0.000]
$\overline{R}^2$	0.971
Q(1)	0.147
Q(5)	4.076
Q(10)	22.60[b]
Â^2	35.28[a] [0.000]
Â$^{2¤}$	7.088 [0.214]
ARCH-LM(10)	6.193 [0.799]

Notes: Newey-West corrected standard errors. p-values in [brackets].[a]; [b] and [c] denotes signi…cance at the 1%, 5% and 10 % level, respectively. Â^2 is a Wald test for the joint signi…cance of the age shares. Â$^{2¤}$ is a Wald test for the joint signi…cance of the dummy-augmented age shares. Sample (adjusted) is 1962:4 - 2000:8.

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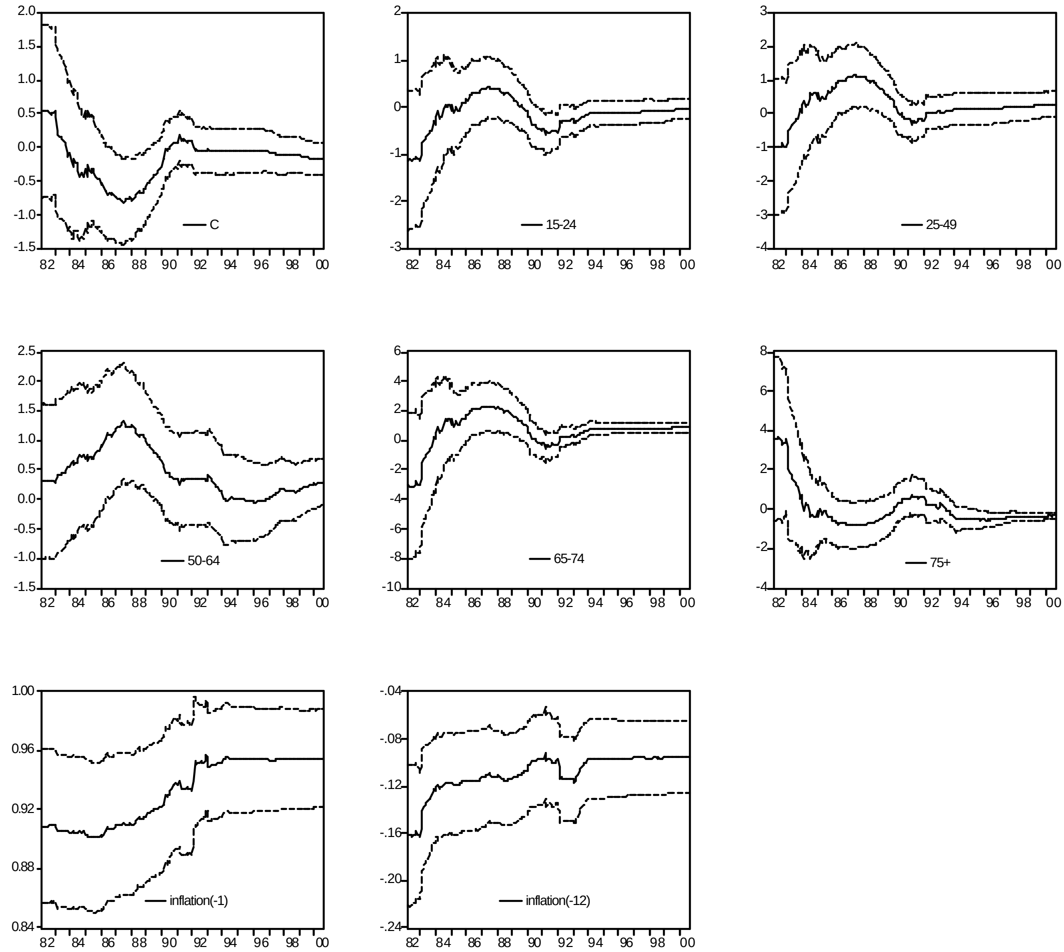

Figure A.1. Recursive estimates 1982:1 - 2000:8 for OLS III.

8 Data appendix

Monthly data on cpi inflation (π_t) runs from 1961:3 to 2000:8 and was supplied from the Riksbank. Data on the three month treasury bills rate (i_t) and the five year government bonds (b_t) can be found in the EcoWin database. All variables are expressed in decimal form. Other variables that have been used in this paper is the natural logarithm of the TCW index ($\ln TCW_t$), the current account balance (CAB_t), the government financial savings (GFS_t), the total industrial production (TIP_t) and the Hodrick-Prescott filtered GDP series ($y - y^*$). All these variables have been supplied by the Riksbank. During the first part of the sample period a proxy for the TCW countries has been used, see Andersson & Österholm (2000) for details. The consensus forecast series and the foa-VAR forecast series were also supplied by the Riksbank.

The input data on the age shares has been supplied by Statistics Sweden and refer to the population on December 31 any given year. This yearly data set runs from 1860 to 2050 where the latest projections run from 1999. After aggregating the …ve-year cohorts into the six age shares, data was interpolated using a quadratic method (see the text). The interpolation procedure can easily be done in the Eviews4 package. For technical information about the interpolation method the Eviews4 help …le is recommended.

The e¤ective estimation period will di¤er slightly across speci…cations due to lags. The data set used in this paper is available from the author on request.

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