BoF Online

7 • 2009

The effect of labour force ageing on productivity in Finland

Charlotta Grönqvist

EUROJÄRJESTELMÄ
EUROSYSTEMET

Bank of Finland

Monetary Policy and Research

15 Apr 2009

Contents

List of charts

List of tables

BoF Online

Editor-in-Chief

Jouko Marttila

ISSN

1796-9123 (online)

Postal address
PO Box 160
FI-00101 HELSINKI, FINLAND

Street address Snellmaninaukio
Phone +358 10 8311
Fax +358 9 174 872

Email
first name.surname@bof.fi
www.bof.fi

Swift SPFB FI HH
Business ID 0202248-1
Domicile Helsinki

1 Introduction

Economic growth depends on how much we work and how productive we are. There is a limit to how much we can work, but productivity can, at least in theory, be increased endlessly. Therefore, understanding productivity, especially total factor productivity, is usually considered more intriguing than calculating the effects of demographics on productivity or economic growth.

In Finland, however, the effects of demographics on the economy have attained much interest lately. The reason is that the population is ageing. Ten years ago people in the working age (15–64 years) amounted to more the 60% of the total population, but in 2018 the share will be less than 55% (Statistics Finland). It is already clear that as a large part of the population consists of retirees, the amount of labour force declines and this puts pressure on public finances, the pension system, and economic growth (Kinnunen 2002, Lassila and Valkonen 2008, Kinnunen 2008). Moreover, as previous research has shown that labour force ageing reduces also labour productivity, there are concerns that an ageing population will decrease economic growth not only via a declining work force, but also via lower productivity (Huovari, Kiander and Volk 2006, Feyrer 2007, Tang and MacLeod 2006).

However, in Finland the active work force will in the future be younger as a large part of the workers become retirees. The share of 50–64 year olds as a percentage of all 15–64 year olds has increased during the last ten years, but will hereafter decline.

The focus of this paper is to empirically investigate how the labour force age structure has affected and will affect productivity growth in Finland. Specifically, I estimate econometrically how the share of hours worked by older workers affects labour productivity. I then use the estimated parameters to forecast the effect of demographic changes on labour productivity in the future.

Population ageing has started before in Finland than in many other European countries. Therefore lessons from Finland from the effects of population ageing on economy will be valuable not only to Finland, but also to other European countries (Huovari, Kiander and Volk 2006).

2 Age and productivity – theories and empirical findings

According to Becker (1962), productivity increases with age because an older work force is more experienced and hence more productive. Medical scientists, on the other hand, stress that cognitive abilities decrease with age and senior workers are therefore less productive than their younger colleagues (Skirbekk 2003).

Many empirical approaches to understanding aggregate productivity growth depart from Solow's (1956, 1957) model of economic growth and use the growth accounting framework. Growth accounting has been employed extensively also on Finnish data. Pohjola (2007) and Junka (2003) look in detail at the factors that have contributed to aggregate productivity in 1976–2005 and 1975–2000 respectively. There are also studies that have used industry level data (Peisa 1994, Jalava 2005, Maliranta 1993, 1995, Sinkkonen 2005). The basic growth accounting framework has often also been the augmented with factors that control for the quality of the inputs. The explanatory variables have been, in addition to capital intensity variables, factors that account for capital and labour quality. Jalava and Pohjola (2004) take into account the quality of labour and in contrast to the aforementioned studies also predict productivity.

However, growth accounting has its limitations. It assumes, inter alia, perfect competition, factor income share being output elasticity, and constant returns to scale. More importantly, growth accounting fails to explain a large part of productivity, ie total factor productivity. This has lead researchers to investigate the effect of specific factors on productivity using econometric models. There is a lot of research studying the correlation between labour productivity and such factors as R&D expenditure[1], patents[2] , competition[3], restructuring[4], and technology diffusion[5].

There is, however, not much research on the effects of the age structure on aggregate productivity in economics. On one hand, there is research on the impact of the age structure on economic growth (Bloom;Canning and Sevilla 2001), income (Malmberg 2002), or on

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[1]Cameron (1998), Griliches and Mairesse (1983), Mairesse (1990), Lööf and Hesmati (2002).

[2] Christiansen (2008) Geroski (1989), Budd and Hobbis (1989), Santarelli and Lotti (2007).

[3] Aghion, Braun, Fedderke (2008), Nickell (1996), Aghion et al. (2005).

[4] Nevalainen (2008).

[5] Stiroh (2002).

individual (Kanzawa 2003) or firm (plant) productivity (Skirbekk 2003, Ilmakunnas and Maliranta 2005, 2007, Ilmakunnas et al. 2004, Malmberg et al. 2005, Daveri and Maliranta 2007). On the other hand, there is research on the effect of population growth (Beaudry and Collard 2002, Beaudry;Collard and Green 2005) or the dependency ratio (Kögel 2005) on labour productivity.

The only work, to my knowledge, that examines the effect of the age structure on labour productivity are Feyrer (2007) and Tang and MacLeod (2006). Feyrer (2007) examines the effect of demographics on multifactor productivity using cross-country data, whereas Tang and MacLeod (2006) use Canadian panel data to study the effect of the older workers on labour productivity. Both studies find that productivity is low for older workers. Tang and MacLeod (2006) also predict labour productivity growth in Canada and find that labour force ageing decreases productivity by 0.13–0.23 percentage points per year in 2001–2011. Also Ilmakunnas and Maliranta's (2007) study on the effect of aging on firm performance concludes that especially in manufacturing ICT industries, firms profit from letting older workers go.

3 Model and estimation

I use an econometric approach in line with Tang and MacLeod (2006) to estimate the effects of the changing age structure on productivity. Specifically, I estimate a production function augmented with the quality of labour and capital, and the business cycle.
The econometric model for industry level labour productivity growth, Δlp_{it}, is:

$$\Delta lp_{it} = \alpha_i + \beta_1 * \Delta 50female_{it} + \beta_2 * \Delta 50male_{it} + \beta_3 * x + \varepsilon_{it}. \quad (1)$$

$50female_{it}$ is the share of hours worked by 50–64 year old female workers in industry *I* at time *t*. Correspondingly, $50male_{it}$ is the share of hours worked by 50–64 year old male workers. *x* denotes other control variables such as capital input, capital and labour quality, and the business cycle. These control variables are described closer below. α_i is the industry specific effect and ε_{it} is an iid distributed error term.

The fixed effects model (industry specific effects) is consistent when estimating parameters for static panel data models. However, there is loss in efficiency when using the within estimator if it is not needed.[6] I test, using the Hausman test, whether the random

[6] Also, it can be biased if the number of time periods is small.

effects model or the fixed effects model should be used, and find evidence in favour for the fixed effects model and it is thus used.[7,8]

The share of hours worked by workers aged 50–64 years is endogenous.[9] The main variables $\Delta 50female_{it}$ and $\Delta 50male_{it}$ are therefore instrumented by the population growth of women ($\Delta pop50f_{it}$) and men ($\Delta pop50m_{it}$) older than 49 years, and the relative share of hours worked by high ($\Delta relhh_{it}$) and low skilled ($\Delta relhl_{it}$) workers in that specific industry. Thus, in this regression there are two endogenous variables and four instruments.
I use the GMM-method to estimate the parameters. The reason for using GMM is that the errors are heteroscedastic and GMM is most efficient when heteroscedasticity is present (Baum;Schaffer;& Stillman 2003).[10]

I also test whether there should be any dynamics. However, I do not find that lagged levels of productivity are significant and therefore only the static model is reported.

4 Data

The data used are industry level[11] data for Finland (EUKLEMS). This database includes growth accounting data between 1970 and 2005. The availability of investment series by asset type and by industry is one of the unique characteristics of this data set.
The dependent variable is industry labour productivity growth in 1971–2005. The average total growth rate in labour productivity was in this period 3%. However, labour productivity growth has declined over the decades; in the 1970s labour productivity growth was on average 3.9%, in the 1980s the growth rate was 3.0%, whereas it in the 1990s and 200s has been below 3%.

The main variables of interest are the share of hours worked by older workers ($\Delta 50female_{it}$, $\Delta 50male_{it}$) The share over hours worked by women aged 50–64 has increased during every decade since 1970. In 1995–20005 this share increased by more than 4% yearly. Also the share of men aged 50–64 has grown by more than 4% during the last ten years, but this share was declining in the 1970s and early 1980s.

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[7] Ho: difference in coefficients not systematic, chi2(7) = 12.18, Prob>chi2 = 0.0949.

[8] For static panel data models, the pooled OLS model is the simplest one. It assumes that there are no specific industry effects and strict exogenous regressors. Thus, it is the most restrictive model as it assumes that regressors are uncorrelated with the errors. This model is rejected.

[9] Ho: difference in coefficients when estimating coefficients with OLS or IV is not systematic. chi2(2) = 8.31. Prob>chi2 = 0.0157.

[10] The p-value of the Pagan-Hall statistic is zero and the null hypothesis of homoscedasticity is rejected.

[11] 1-digit TOL 2002.

As the main variables of interest are found to be endogenous they are instrumented. Instrumental variables must be correlated with endogenous variables and orthogonal to the error term in order to be valid. The instrumental variables are growth rate of male and female workers aged 50-64 ($\Delta pop50m_{it}, \Delta pop50f_{it}$) and the share of high skilled and low skilled workers ($\Delta relhh_{it}, \Delta relhl_{it}$), working in the industry relative to the whole economy. The results from the tests whether these instruments used are valid, are depicted in appendix. These results suggest that the instruments chosen are not weak and that the equations are identified. The first stage regressions results also show that the t-values for instruments are more or less significant.

The control variables x, control for capital, heterogeneity in both capital and labour input, and for the business cycle. Previous research on capital's effect on labour productivity has focused on differences between IT and ICT investment in comparison to other investment. This is because IT and ICT sectors are thought of being the driving force behind the surge in productivity (Stiroh K. 2002). Inklaar, Timmer and Ark (2008) investigate the productivity in the market services sector using cross sectional data from Europe and US and find according to the prediction by Jorgenson and Griliches (1967) that there is a big difference between ICT and non-ICT capital to growth in Finland in 1995-2004. Also Forsman and Jalava (2006) find that the ICT sectors accounted for almost 40% of the labour productivity growth in Finland in 1995-2000. I therefore differentiate between ICT assets (∆ICT) and non-ICT assets (∆nonICT). ICT asset growth has been much faster (13.7%) than non-ICT asset growth (1.5%) in Finland in 1971–2005.

Investment in labour quality can be done via e.g. education, job training, labour migration, health care etc. (Stiroh K. J., 2001). Schwedt and Turunen (2006) find that labour quality accounts for a significant amount of labour productivity and Tressel (2008) finds a relationship between human capital and labour market productivity. Ratinen (2008) finds that the labour quality growth has been 0.4% during 1995–2005 in Finland. I proxy labour quality (human capital) by the relative wage (Δwage). The relative wage is the average wage in the industry in relation to the average wage in the whole economy.

Finally, I take into account the pro-cyclicality of productivity growth. I do this because labor productivity is very volatile and this cannot be explained by differences in technology, labour or capital. Also, endogenous growth models suggest that factors behind productivity growth are affected by the business cycle (Smolny 2000).

I measure the pro-cyclicality by the change in the unemployment rate (Δunempl) and I also include, as does Smolny (2000), a lagged level of the business cycle indicator (unempl_1). The current business cycle variables tests whether there are short run effects of the business cycle whereas the lagged level is an indicator for whether there are log run effects of the business cycle on productivity.

5 Results

The regression results from equation (1) are depicted in Table 1.[12] The variables of main interest are $\Delta 50\ male$ and $\Delta 50\ female$. The coefficients on the (change in the) share of working females and males aged 50 to 64 are negative (-.21 and -.23). This means that the larger the growth of these shares, the lower is labour productivity growth. The result corresponds to previous findings and suggests that older workers are less productive than younger workers (Feyrer 2007, Tang and MacLeod 2006).

Capital intensity affects productivity the most (.312 and .035). The size of capital intensity is of the same order as in Smolny (2000). The coefficient is fairly close to the share of capital income in value added in the beginning of the period. However, the capital income share one gets from growth accounting has increased over the years and the coefficient being smaller here indicates that the elasticity of labour productivity growth with respect to capital intensity growth is smaller than one gets from the growth accounting framework.

Also the relative wage of the sector has a significant impact on labour productivity of the sector (.22). This indicates that differences in human capital are important for industry-level labour productivity. However, it is not as large as found in Smolny (2000). Here the coefficient is smaller than that for physical capital and this indicates that it has not been as important as capital input.

The business cycle affects productivity in the short and long run. The current change in unemployment rate has a negative impact on labour productivity (-.028). This result corresponds to Tang and MacLeod (2006). However, the unemployment level has a large positive impact on labour productivity (.276). This means that productivity is high when unemployment is high. This result may be due to the fact that there was a large structural change during early 1990s when redundant industry production was replaced by high technology and services. During this period unemployment and productivity growth was high. Dew-Becker and Gordon (2008) regress the effect of employment on productivity, and find similarly that during low employment there is high productivity.

[12] The first stage regressions are depicted in the Appendix (part 1 and part 2).

Table 1. Regression results

2-Step GMM estimation

Estimates efficient for arbitrary heteroskedasticity
Statistics robust to heteroskedasticity

		Number of obs =	471
		F(7, 450) =	5.44
		Prob > F =	0.0000
Total (centered) SS	= 1.309029504	Centered R2 =	0.0870
Total (uncentered) SS	= 1.309029504	Uncentered R2 =	0.0870
Residual SS	= 1.195193875	Root MSE =	.05114

LPgrowth	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Δ50 male	-.209555	.2658978	-0.79	0.431	-.7307052	.3115952
Δ50 female	-.2329934	.1591019	-1.46	0.143	-.5448274	.0788407
ΔICT	.0354348	.0144165	2.46	0.014	.007179	.0636906
ΔnonICT	.3115151	.1001872	3.11	0.002	.1151519	.5078783
Δwage	.2230284	.0962098	2.32	0.020	.0344607	.4115961
Δunempl	-.028319	.0111859	-2.53	0.011	-.0502429	-.006395
unempl_1	.2761851	.1090582	2.53	0.011	.0624349	.4899353

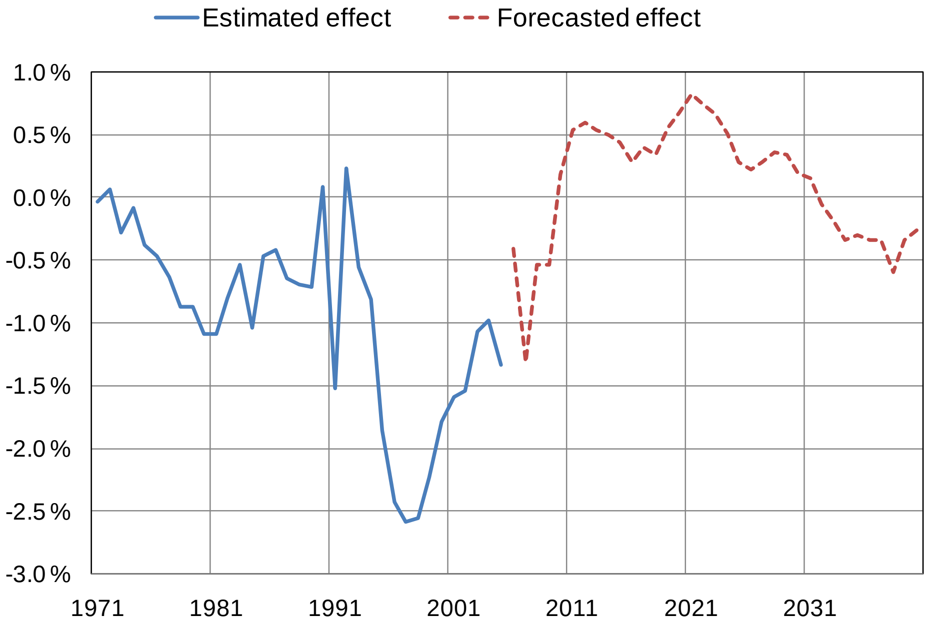
6 Impact of labour force ageing in the future

One central question of this paper is how the changing age structure will affect labour productivity in the future. I calculate the impact of the ageing work force using the Statistic Finland's 2007 population forecast. Everything else, including the level of skills, is assumed constant.

Chart 1 shows the calculated and estimated effect from the change in the age structure of the work force on labour productivity. 1970–1990, labour productivity growth declined by 0.5 percentage points on average annually in response to population ageing. In 1991–2005, when the population was ageing very quickly, the annual effect of demographic change on labour productivity was -1.5 percentage points, on average. Labour productivity increased at an average rate of 3.4% per annum over the years 1970–1990, while the annual growth rate for 1991–2005 was 2.9% on average. Hence, potential labour productivity declined by 14% over the years 1970–1990 in response to population ageing, while more than one third of potential productivity growth was lost over the years 1991–2007 because of the ageing of the population.

In the future, a decline in labour productivity due to population ageing will no longer be a problem in Finland. Hence, contrary to general belief, the demographic changes will have a positive effect on labour productivity in the future as the share of older workers of the whole labour force is declining. The changing demographic structure will increase labour productivity between 0.2 and 0.7 percentage point per year in 2010–2020.

Chart 1. Impact of labor force ageing on productivity growth



Source: Bank of Finland calculations.

7 Summary

I have estimated the effect of the labour force age structure on labour productivity using Finnish industry level data for 1970–2005. This is especially interesting for Finland because the population is ageing here before than in many other European countries. Whereas ten years ago people in the working age (15–64 years) amounted to more the 60% of the total population, in 2018 the share will be less than 55%. However, in Finland the active work force is becoming younger as a large part of the workers become retirees. The share of 50–64 year olds as a percentage of all 15–64 year olds has increased during the last ten years, but will hereafter decline.

I found that the effect of an older labour force has been negative during 1995–2005. However, starting from 2010, the effect from demographic changes will be positive in Finland. Specifically, the changing demographic structure will increase labor productivity between 0.2 and 0.7 percentage point annually in 2010–2020.

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Appendix

1. First-stage regression of Δ50 male:

OLS estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	471
		F(9, 448) =	37.55
		Prob > F =	0.0000
Total (centered) SS =	.6205100191	Centered R2 =	0.3714
Total (uncentered) SS =	.6205100191	Uncentered R2 =	0.3714
Residual SS =	.3900341217	Root MSE =	.02951

dhour50m	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ΔICT	-.0009604	.0059005	-0.16	0.871	-.0125566	.0106358
ΔnonICT	.0580472	.0326052	1.78	0.076	-.0060309	.1221253
Δwage	-.0193175	.0427255	-0.45	0.651	-.1032849	.0646498
Δunempl	.0143141	.0063616	2.25	0.025	.0018118	.0268163
unempl_1	.1993694	.0755896	2.64	0.009	.0508151	.3479237
Δpopul50m	2.177462	.320721	6.79	0.000	1.547157	2.807766
Δpopul50f	-.9604036	.272122	-3.53	0.000	-1.495198	-.4256096
Δrelhh	.2839733	.0783661	3.62	0.000	.1299625	.4379841
Δrelhl	.1427053	.1359809	1.05	0.295	-.1245343	.4099449

Included instruments: dICT dnonICT dwage dlnsuhd unempl_1 dpopul50m dpopul50f drelhh drelhl

Partial R-squared of excluded instruments: 0.1834
Test of excluded instruments:
F(4, 448) = 20.21
Prob > F = 0.0000

```
2. First-stage regression of Δ50 female:

OLS estimation
--------------
Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

                                                      Number of obs =      471
                                                      F(  9,    448) =     6.18
                                                      Prob > F      =   0.0000
Total (centered) SS     =  1.383360643                Centered R2   =   0.1729
Total (uncentered) SS   =  1.383360643                Uncentered R2 =   0.1729
Residual SS             =  1.144126192                Root MSE      =   .05054

------------------------------------------------------------------------------
             |               Robust
    dhour50f |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ΔICT |  -.0088345   .0103288    -0.86   0.393    -.0291335    .0114645
     ΔnonICT |   .0123672    .048527     0.25   0.799    -.0830017    .1077362
       Δwage |  -.0511273   .0528513    -0.97   0.334    -.1549946      .05274
     Δunempl |   .0243399   .0086782     2.80   0.005     .0072849    .0413949
    unempl_1 |  -.1406806    .151888    -0.93   0.355    -.4391821    .1578209
   Δpopul50m |    .712848   .4672047     1.53   0.128    -.2053371    1.631033
   Δpopul50f |   .7432339   .4187565     1.77   0.077     -.079737    1.566205
      Δrelhh |   .3990871   .2080515     1.92   0.056    -.0097909    .8079652
      Δrelhl |   .7550822   .3063706     2.46   0.014     .1529802    1.357184
------------------------------------------------------------------------------
Included instruments: dICT dnonICT dwage dlnsuhd unempl_1 dpopul50m dpopul50f
                      drelhh drelhl
------------------------------------------------------------------------------
Partial R-squared of excluded instruments:   0.1517
Test of excluded instruments:
  F(  4,   448) =     6.85
  Prob > F      =   0.0000



3. Summary results for first-stage regressions
-------------------------------------------

Variable     | Shea Partial R2 |   Partial R2    |  F(  4,   448)    P-value
dhour50m     |     0.1152      |     0.1834      |       20.21       0.0000
dhour50f     |     0.0953      |     0.1517      |        6.85       0.0000

NB: first-stage F-stat heteroskedasticity-robust

Underidentification tests
Ho: matrix of reduced form coefficients has rank=K1-1 (underidentified)
Ha: matrix has rank=K1 (identified)
Kleibergen-Paap rk LM statistic            Chi-sq(3)=9.79     P-val=0.0204
Kleibergen-Paap rk Wald statistic          Chi-sq(3)=12.53    P-val=0.0058


Weak-instrument-robust inference
Tests of joint significance of endogenous regressors B1 in main equation
Ho: B1=0 and overidentifying restrictions are valid
Anderson-Rubin Wald test     F(4,448)= 3.43      P-val=0.0090
Anderson-Rubin Wald test     Chi-sq(4)=13.98     P-val=0.0074
Stock-Wright LM S statistic  Chi-sq(4)=11.95     P-val=0.0178

Hansen J statistic (overidentification test of all instruments):        3.446
                                                   Chi-sq(2) P-val =    0.1785
```