Michael Kuhn
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Labour Markets and Demographic Change

DEMOGRAFISCHER WANDEL –
HINTERGRÜNDE UND HERAUSFORDERUNGEN

VS RESEARCH

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Introduction

The demographic change in the industrialised countries changes the relative population shares of younger and older people. This equally applies to the working age population and, hence, to labour supply. For example, the ratio of the age groups 15 to 39 and 40 to 64 declined between 1978 and 2005 from 1.7 to 1.0 in Canada, from 1.2 to 0.9 in Germany, from 1.4 to 1.0 in Japan, and from 1.5 to 1.0 in the US. This trend will continue over the next 20 years due to low or even diminishing fertility rates. As (un)employment-related characteristics of younger and older workers differ, ageing has profound consequences for the workings of the labour market and its outcomes. Demographic processes touch directly on labour supply and demand, thus driving employment and unemployment. By shaping the productivity profile of companies, regions and countries, as well as their propensity to innovate, age structure emerges as a crucial determinant for corporate competitiveness and economic development. Changing population structures have an impact on the incentives to accumulate and transfer knowledge, again bearing on the scope for sustained economic growth. Finally, issues arise about whether the shortfall of young and middle-aged workers within an ageing economy can be offset by a better integration of female, foreign and older workers. This volume provides a collection of research papers on a range of salient issues related to labour markets and demographic change. The papers were presented during the 2nd European Workshop on Labour Markets and Demographic Change held at the University of Rostock in May 2007 and co-sponsored by the University of Rostock, the Max Planck Institute for Demographic Research and the Rostock Center for the Study of Demographic Change.

Chapter 1 opens with an assessment of the age structure of employment and unemployment. Golo Henseke, Pascal Hetze and Thusnelda Tivig use different measures of ageing to obtain a detailed picture of the ageing process between 1975 and 1995 of the workforce employed in German industries. The results reveal pronounced differences across sectors and industries in the age composition and the dynamics of ageing. Furthermore, fast ageing is associated with large shifts in the middle-age groups, whereas slow ageing rather relates to changes in the margins of the age distribution. Carsten Ochsen examines how the level of unemployment depends on the distribution of unemployment by age. Using an extension of the standard equilibrium unemployment model he finds for a set of OECD countries that the distribution of unemployment by age has a hump-shape effect on the unemployment rate.

The focus of Chapter 2 lies on the relationship between age structure and productivity at the firm level. Matthias Weiss analyses the relation between workers' absenteeism and age diversity. Age-diverse teams are sometimes advocated as a means to improve productivity. According to the results, however, age diversity is

detrimental to productivity in that it leads to more absenteeism. Bernhard Mahlberg, Inga Freund and Alexia Prskawetz assess the relationship between a firm's productivity level and the age composition of its employees using a matched employer-employee data set for Austria. It is their objective to test whether the hump-shaped age profile of the employees' age structure on labour productivity is robust once controlled for training intensity. They find a simultaneous, negative productivity effect of the share of young workers and older workers on labour productivity in samples of small and large firms alike. Using data of German ICT- and knowledge-intensive service providers, Jenny Meyer finds that the age of the workforce affects the probability to adopt new or significantly improved technologies. Firms with a higher share of younger employees are more likely to adopt such technologies. As it turns out, however, the impact of age structure on the propensity to adoption depends crucially on the organisation of firms. Thus, an older workforce fosters adoption in firms relying on flat hierarchies or on teamwork.

Chapter 3 deals with the effects of ageing on innovation. Golo Henseke and Thusnelda Tivig analyse whether and how an ageing and shrinking population is significantly related to the innovation process. Based on their empirical analysis they confirm past conjectures stating that inventive productivity is age-dependent and unequally distributed among inventors. Using a regional knowledge production function to explain patenting activity in German districts, Katharina Frosch and Thusnelda Tivig show that age affects patenting performance through two channels, namely the regionally available stock of age-specific human capital and the age structure of the labour force itself.

The role of demographic processes for human capital accumulation is studied in Chapter 4. Michael Kuhn and Pascal Hetze examine the transfer of know-how from old and experienced workers to their junior co-workers, whether it is efficient and how it is affected by the ageing of the workforce. They show how the knowledge transfer can be understood as an intertemporal market, where lower future demand for know-how due to a lack of young workers reduces the current incentives to invest in know-how. Francesco Lancia and Giovanni Prarolo provide a positive theory that explains how an economy might evolve when the longevity of its citizens both influences and is influenced by the process of economic development. The model focuses on the crucial role played by heterogeneous interests in determining innovation policies, which are one of the keys to the growth process: The economy can be discontinuously innovation-oriented due to the different incentives of individuals and doe to different schemes of political aggregation of preferences. Christian Lumpe and Benjamin Weigert analyse the impact of high skilled immigration on native human capital investment in a search-theoretic model. They show that high skilled immigration leads to rising educational attainment of natives.

Chapter 5 is devoted to issues in female labour supply. Elena Vidal Coso, Fernando Gil Alonso and Andreu Domingo i Vals apply factor analysis and linear

multiple regressions to 2006 data from the Spanish Labour Force Survey (EPA) in order to identify the determinants of the regional distribution of the working age extra-communitarian female population. Results relate to the relationship at the level of province between the workforce share of extra-communitarian women and the demographic and labour characteristics of each province and the characteristics of the female autochthonous workforce (education level, degree of occupational qualification, activity rates). Anna Matysiak and Daniele Vignoli undertake a meta-analysis of published research on the relationship between women's employment and their fertility. Their results suggest that this relationship is strongly conditioned by the institutional context and that it has changed over time even when controlling for context. This implies that regional and/or temporal variations in institutional factors, structural factors and socio-cultural factors have been important in determining the magnitude of the conflict between work and family.

Finally, in Chapter 6 two aspects of retirement are analysed. Martin Brussig and Christina Wübbeke study the recent German labour market policy of 'facilitated receipt of benefits (FRB) without an obligation to seek employment' as a pathway to retirement for the unemployed aged 58+. Using data from a cross-sectional labour force survey, they study the socio-economic determinants for participation in the FRB programme. One main result is that FRB should be viewed as a route towards involuntary early retirement rather than as a way of avoiding the employment agency's pressures to search for a job. Francesca Rinesi analyses the employment state transition of older workers (50 to 64) in Italy. She concludes that for old workers of both sexes the Italian labour market has become even less dynamic over the 1990s. In particular, for female workers the risk to exit the labour market has decreased from a higher level at the outset towards the level of male workers. A regression analysis identifies age, education, industrial sector and part-time employment as key determinants of retirement for both sexes, whereas male retirement is also driven by economic factors and geographical location.

It is obvious that this book can only provide selective insights into the role of demographic developments for the labour market. More work is needed to get a deeper understanding of this complex set of issues at the interface of economics and demography. Nevertheless, we are convinced that the volume provides an insightful introduction to the topic and that it manages to match the multitude of research questions with an equally broad array of methods.

Acknowledgement: The editors would like to express their thanks to the Rostock Center for funding this publication and contributing towards the funding of the workshop, and especially to Juliane Steinberg and Marlen Toch for managing so effectively the editorial process.

Michael Kuhn und Carsten Ochsen

I. The Age Structure of Employment and Unemployment

Ageing in German Industry

Golo Henseke, Pascal Hetze, Thusnelda Tivig

1. Introduction

German population ages at high pace. Life expectancy at birth that was 68.6 years for men and 75.2 for women in 1975 is projected to rise to 83.5 to 85.4 and 88 to 89.8 for women until 2050.[1] In addition to increasing longevity, most Western societies are ageing because of low fertility, implying decreasing shares of the young in total population. Ageing, as well as the accompanying perspective of shrinking,[2] pose major problems for social security systems and it is believed to threaten, in the long run, innovation and growth. In a medium term perspective, political interest in ageing focuses on labour market effects and infrastructure planning.[3] To assess labour market effects it is necessary to know where exactly, (in what industries, professions and regions), how fast and why population ages. However, it is not possible to directly infer the direction and extent of ageing in the workforce from population ageing. One reason is the existing time lag: Changes in birth rates take around 20 years to appear in the age composition of the workforce. Another reason is that increasing life expectancy is of no importance for the workforce unless it concerns mortality of those still active. In general, the date of exit from the labour market is defined by retirement, not by mortality, and retirement age has rather decreased in Germany.[4] Finally, mean age of the labour force does not directly reflect mean age of population because it might change without any underlying demographic change. For example, it could simply increase because of longer edu-

1 See the 11th coordinated population projection of the German Statistical Office. http://www.destatis.de/presse/deutsch/pk/2006/bev_2050b.htm

2 The German population is shrinking since 2005. However, without migration, Germany would have lost population since the early 1970s.

3 See e.g., Börsch-Supan (2003) or Dixon (2003) for an overview of labour market effects of ageing and Henseke and Tivig (2007) for industry-specific aspects of the innovation-ageing link.

4 In Germany, the age of retirement was highest in the beginnings. When Bismarck first introduced social security, the regular retirement age was 70, whilst life expectancy at birth was 37.2 years for men and 40.3 years for women. The lowest average actual retirement age (considering the period after Reunification, only, and ignoring retirement caused by disability) occurred at around 62 years for men and women in 1997-1999. See a.o., Hubrich and Tivig (2006) for details. For labour market and political causes of early retirement see, for example, Börsch-Supan and Schnabel (1998).

cation periods or increasing labour market participation of older workers. For this reason we henceforth refer to the working age population (here: 18 to 62 years) as a point of reference instead of total population because the different subgroups of our analysis then face the same demographic and economic impacts.[5]

And indeed, the pure demographic effect on labour force ageing in Germany has been only weak to moderate over the last decades, but with clear gender specific differences in magnitude (Henseke et al. 2007). Mean age of the working age population (population aged 18 to 62 years[6]) increased slightly between 1975 and 1995/2001, namely from 38.4 to 39.4/40.2. However, there are a lot of dynamics hidden behind this minor increase. Employees are younger than total labour supply, unemployed even more so and both groups age faster than the reference group. Considering the educational level, we see that highly educated workers are older than lower educated ones, but the increase in mean age is more moderate.

The aim of this paper is to analyse the process of ageing in German industries by using adequate measures. There are a few papers in the literature dealing with related topics. Naegele (2001) uses official German statistics to point towards the fact that mean age depends on firm size, because employment chances for the older are higher in small and middle-sized firms. Brasche and Wieland (2000) use a similar data set to ours when referring to industries but for period 1990-1995 and demonstrate that small (less than 100 employees) firms' age distribution has preserved its "second age peak" at age 50 to 54 whereas it has disappeared in the age distribution of all other (larger) firms. At the same time they picture some industry-specific age profiles but do not inspect them closer. Niebuhr and Stiller (2005) compare German regional age-specific labour force data and draw conclusions about expected regional labour shortage. Orzechwska-Fischer (2004) performs a comparative study for Japan over the period 1960 to 2000 and Australia over 1971-2001. She considers eleven industries, mostly grouped into primary, secondary and tertiary. In 2000, Japanese tertiary industries changed roles with secondary ones that had been youngest in 1960. In Australia, tertiary industries had always been youngest. In Japan grid-bound infrastructures (electricity, gas and water supply: median age 41.1 in 2000) had the youngest employees, closely followed by services (median age 41.8 in 2001), whereas in Australia wholesale, retail and trade as well as finance, insurance, property and business were among the industries with lowest median age (34.2 and 38 years, respectively). Furthermore, she conducts decomposition analysis of employ-

5 See Morrison (1983) for a compact and insightful study of human resource implications of ageing of the U.S. population. The author stresses the importance of age-specific labour force participation rates and predicts: "Reduced labor force participation may well characterize the older population seemingly irrespective of various labor shortages and increases in demand for workers that might develop over the next two decades" (Morrison 1983: 16).

6 The restriction to age group 18 to 62 is subject to data availability. See Section 2.1 below.

ment rates to disentangle age composition effects from employment effects. Her results show that for most industries the demographical effect tended to be unfavourable; ageing of the labour force favoured employment in primary industries, only. However, for tertiary industries the employment effect acted in the opposite direction. Using a similar technique for the German workforce, Henseke et al. (2007) show that between 1985 and 2005 demography had a clear, though moderate, negative impact on the share of male employees. Changes in female employment were, to the contrary, de facto unaffected by demography and dominated by behavioural effects. Remarkably, demographic change did not affect the share of unemployed persons, no matter their sex.

The paper is organised as follows. Section 2 introduces data and methods. Section 3 presents the results for sectors and industries. Section 4 concludes.

2. Data, Definitions and Method

2.1 Data

In this paper we analyse the age composition of subgroups of the employed and registered unemployed, taken together. The subgroups are defined by attributes like industrial sector and knowledge intensity of industries. The analysis is focused on comparison of the first and last available year.

We use the basic file of the employment sample from the Institute of Employment Research (IAB). The employment sample is drawn from the IAB employee history, supplemented by information on unemployed persons from the IAB recipient history. The basic file is a 1% sample that spans 21 years, from 1975 to 1995 and allows detailed classification of industrial sectors, as needed for the present study. We only consider employed persons aged 18 to 62 years, because employment is low beneath and above these margins.

2.2 Definitions

As our data set is based on administrative social insurance data, we concentrate on employees and registered unemployed. Employees are all employed persons who are liable to contributions to the social security system. This group does not, for example, encompass students, public officials and self-employed persons. Unemployed, in this framework, are people who work less than 15 hours per week, are job-seeking and draw benefits from the Federal Employment Office. The reference

group in the following sections is the total employment sample with the exception of those only marginally employed.[7] The classification of industries is based on the two-digit taxonomy of 1973 (WZ73). For the purpose of this study we aggregated the industry classification into 32 sectors of which we selected 19 for detailed investigation.

2.3 Measures of Ageing

The age composition of active population is more volatile over time than that of total population. The reason is the discontinuous nature of demographic and socio-economic processes. Changes often appear in cycles or are concentrated at certain points in time. An example would be the entrance of baby boomers into labour markets or German early retirement policy in the 1990s. As a consequence, some measures lose their analytical power since they sometimes overrate or even ignore developments. This is particularly true for mean age, which hides the age distribution of population. For example, this indicator does not differentiate between two groups, one homogenously consisting of 40 years old workers and the other one being divided into one half of 20 years old and the other half of 60 years old workers; mean age in both groups is 40, though economic needs concerning professional training, innovativeness or tenure would be different.

Changes in labour market participation may also bring about that ratios between young and old, taken alone, give a wrong impression of ageing. For instance, a prolonged duration of educational attainment will reduce the number of persons under 25 as compared to higher age groups and imply significant ageing of active population. The effect diminishes, of course, if we consider the ratio of persons under 40 to higher age groups, instead. However, a measure that compares margins of age distributions is an important lead indicator. For instance, it appears to be highly economically relevant if the human capital stocks of young and old workers are only imperfect substitutes[8]. For these reasons we use and construct different measures of ageing that we present below.

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7 This group, called "geringfügig Beschäftige" in German, is excluded because it is registered statistically only from 1999 onwards. A marginally employed person earns no more than 400 Euro per month.

8 See, for example, Fitzenberger and Kohn (2006). They estimate with a comparable data set to ours elasticities of substitution among different skill groups which are themselves separated by age. Their findings confirm indeed that employees of different age are imperfect substitutes. Interestingly, the elasticities of substitution between ages are lowest among vocational trained employees.

Mean Age
Mean age allows a quick albeit rough overview and comparison of ageing across subgroups. Its shortcomings are, as already mentioned, disregard of underlying age compositions and hence underestimation of economically relevant changes.

Ratio 1: 18 to 39 years old persons / 40 to 62 years old persons
Ratio 1, R(1), represents the age structure on a broad base. Changes in this figure are dominated by changes in the middle of the age distribution because the middle age groups outnumber the rest. Shifts reflect, e.g., the ageing of the baby boomer cohorts. The measure is economically relevant when people change behaviour in the second part of their professional career-like, for instance, change their job-related and regional mobility or get a stronger motivation to work.

Ratio 2: 18 to 29 years old persons / 50 to 62 years old persons
Ratio 2, R(2), is particularly sensitive towards socio-economic changes, like early retirement and longer educational periods. But it is as well a lead indicator of demographic change, revealing shortage of young people that will change the future age structure.

Index of Ageing
To give a compact representation of differences in the age distribution of a subgroup compared to a reference group, we construct an index of ageing:

$$I = 100 \sum_{a=18}^{a=62} \left(p_{i,a} - \tilde{p}_a \right) ln\left(\frac{a}{\tilde{a}} \right),$$

where a represents the age of an age group, $\tilde{a}$ is the mean age of a reference group, $p_{i,a}$ is the share of age group a in subgroup i and $\tilde{p}_a$ is the corresponding share of age group a in the reference group. If the share of an age group in the subpopulation under investigation is below the corresponding share in the reference group, it will sum up to a negative value and the other way round. Accordingly, an index value of zero implies an age structure equal to the reference group, while a negative (positive) value stands for a relatively young (old) subpopulation.

Due to the logarithm, I is a concave function in a. Shifts in higher age groups will thus have a lower weight. As such, the index is more an index of youth. Under the assumption of an equal mean age of two subpopulations, a negative (positive) value points to higher (lower) densities at the margins of the distribution. The choice of a reference group allows comparison of the index at different moments. The difference will show whether relative changes occurred as compared to the reference group. Precisely, a rise (fall) in the index indicates that the subpopulation

aged relatively fast (slow), which is less the result of demographic processes, but more of shifts in economic decisions or individual behaviour.

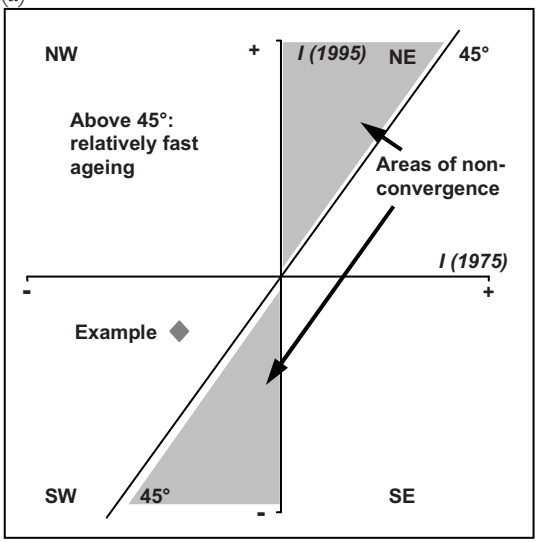
Graphical Representation

In Figures 2a and 3a of Section 3 we display the index *I* at two different dates. The old value is plotted on the abscissa, the new value on the ordinate. This type of figure contains information about the age structure and its changes within the observation period. It allows the following interpretation (take Figure 1a as an example): All data points in the North-East quadrant (NE) show an age distribution, which is at both times older than the reference group. In the North-West quadrant (NW) values are plotted for subgroups that were younger than the reference group in the past but are older at the end of the observation period. In the South-West quadrant (SW) subgroups were younger at both moments. Finally, a position in the South-East quadrant implies a relative old age structure in the past which has become relatively younger over time. Additionally, values below and above the (prolonged) 45°-line give information about the relative shifts in the age distribution. All values above this line represent subpopulations that aged faster than the reference group, while values below the 45°-line reveal a relatively slow ageing process. For example, the data point in Figure 1a in the SW tells that this subgroup has been younger than the reference group at both points in time. But because it is positioned above the 45°-line, it has aged faster than the reference group. A movement towards the average has taken place.

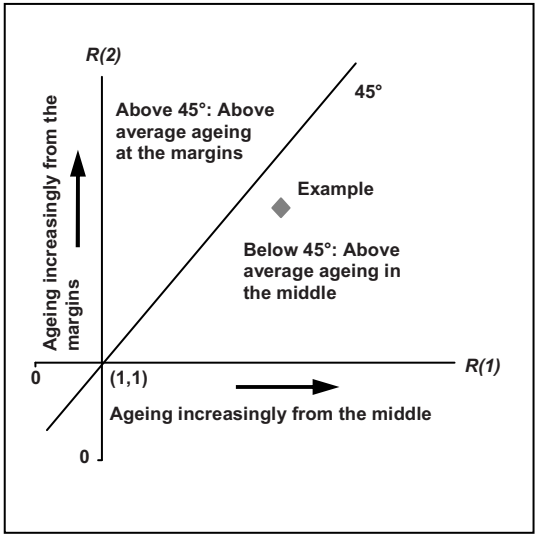
In part (b) of the following figures we illustrate a comparison of relative changes in Ratios 1 and 2. On the abscissa, we plot the quotient of group-specific changes in Ratio 1 to the average change of R(1). In the same way, values for Ratio 2 are calculated and plotted on the ordinate. These figures help displaying which segments of the age structure are particularly affected by ageing and to what extent. For exemplification please use Figure 1b. The more to the right and the higher above the origin (which is scaled to one) a data point lies, the faster the corresponding subpopulation ages as compared the reference group. The ratio of R(1) to R(2) provides information about the segment where ageing mainly occurs, that is, whether it is dominated by shifts in the middle or at the margins of the age distribution. Above the 45°-line, R(2) declines faster than R(1) as compared to the reference group; this means that changes occur more at the margins than in the middle of the age distribution, always compared to the reference group. Below the 45°-line changes are mainly determined by shifts in the middle of the age structure. The subpopulation referred to in Figure 1b is thus ageing stronger than average, both, at the margins and in the middle of the age distribution. But the overall ageing process is dominated by strong shifts in the middle of the age distribution.

Figure 1: Index of Ageing and R(1)/R(2) – Comparison

(a)



(b)



When interpreting the results below, we have two hypotheses on ageing in mind. First, we set the hypothesis that there is a convergence tendency towards a homogenous age structure, implying that older subgroups of the workforce age slower whilst younger ones age faster. Hypothesis 1 can be firstly checked by expecting figures of type (a) and is secondly directly tested in the last column of each table; a zero means that the hypothesis is formally violated. In Figure 1a the areas of non-convergence are shaded. Hypothesis 2 claims that groups that age relatively fast do so from the middle of the age distribution whereas those ageing slower age from the margins. Checking Hypothesis 2 needs combined information from both types of figures, (a) and (b). If it holds true, data points located above the 45°-line in figures of type (a) should be found situated below the 45°-line in figures of type (b). Below, the data point taken as an example fulfils this expectation.

3. Results

In this section we present our results of ageing in German industries and sectors. We show that the age compositions of sectors differ to an extent that almost allows interpreting the notions "new and old economy" demographically. For simplicity, we call the reference group labour force henceforth, but remind the reader that it is only a rough measure since it includes neither self-employed and public officials nor non-registered unemployed and persons belonging to the hidden reserve in general. Available data starts 1975 and ends 1995. For the sake of clarity we do not differentiate for gender. Mean age of our reference group increased from 36.8 in 1975 to 39.3 years in 1995 that is by 6.6 %. The ratio R(1) of age group 18 to 39 to age group 40 to 62 diminished by 19.4 % whereas the ratio R(2) of age group 18 to 29 to age group 50+ decreased by almost 38 %. Hence, accelerated ageing can be observed between 1975 and 1995, in general. However, as we show below, ageing processes differed heavily across sectors and industries.

3.1 Knowledge Intensity and Sectoral Differences in Ageing

How much ageing affects a firm's economic outcomes essentially depends on knowledge intensities and may hence be more pronounced in highly innovative sectors.[9] The reason for this is that acquisition of new (formal) knowledge occurs predominantly at younger ages whereas professional experience naturally increases

9 For studies of the age-innovation link in different professions see a.o. Jones (2005), Lehman (1966) and Levin and Stephan (1991). Henseke and Tivig (2007) perform an industry-specific age innovation study with German patent data.

with age. In what follows, we classify manufacturing industries and services according to their share of engineers and university graduates, in total sectoral employment in 1995. Industries locatedin the 75% (25%)-quartile of the respective distribution are qualified as high-tech (low-tech), the rest as medium-level knowledge-intensive.

Services

Results are given in Table 1 and Figure 2. Table 1 shows that age composition is very homogenous in services. The sector was and continues to be younger than the reference group but it has aged faster than average. Column 1 of Table 1 shows the level of mean age at the beginning and end of the observation period and its increase throughout. Compared to values of the reference group (the shaded first row), only industries with a medium-level knowledge intensity age at an almost average rate, whereas low-tech services industries age at a rate 44 % higher than average. Comparing the values of ratios R(1) and R(2) (columns 2 and 3 in Table 1) reveals that ageing took place both from the middle and from the margins of the age distribution, whereby the shifts of the latter are, as expected, considerable stronger. Finally, the ageing index (last column) yields a compact picture of what was already said: All service industries were and remained younger than the reference group (all left-hand values in the last column are negative) but the ageing process took place faster than on average (all right-hand values in the last column are positive).

Figure 2 illustrates these ageing effects more directly and gives additional information on relative ageing. In Figure 2a all services are located in the South-West region, independent of their knowledge intensity. That is, these industries were and remained younger than the reference group. Additionally, their location above the 45°-line tells that they were ageing at a faster pace than the reference group. Hence, Hypothesis 1, saying that there is a convergence trend towards a homogenous age composition, receives support. Figure 2b reveals that ageing in all services is dominated by ageing from the middle of the age distribution (all points are located below the 45°-line) and that this effect is strongest for high-tech industries (their data point is located the farthest to the right), hypothesis 2 also receives support.

Manufacturing

Ageing in manufacturing is less homogenous and results offer some surprises (see Table 1). Interestingly, low-tech industries were and remained youngest as compared to high- and medium-tech and still aged slower within the 20 years of observation than the reference group. A possible explanation is the importance of physical performance in these industries. Mean age in high-tech industries increased, to the contrary, and was 40.4 in 1995, which is one year more than the 39.3 years average of the reference group. With 9.2 % the increase in mean age was highest for high-tech industries.

Looking at the values of the ratios R(1) and R(2) in columns 2 and 3 of Table 1 reveals that overall ageing in this sector was fed by both: ageing in the middle and ageing at the margins of the age distribution, with R(2), being twice to three times stronger than R(1). The ageing index again synthesises the ageing process. Left-hand values in the index column are negative for low-tech industries, only; this corresponds to the information that they were and remained younger than the reference group, whereas higher-tech industries were and grew comparably older. The positive values of the change in the age index for middle- and high-tech industries in the manufacturing sector (the right-hand figures in the index column of Table 1) reveal that ageing accelerated as compared to the reference group.

Table 1: Changes in the age composition of industrial sectors (manufacturing and services)[10]

		Mean Age		Ratio 1		Ratio 2		Index		Hypothesis 1
			change in %		change in %		change in %		absolute change	
Average	1975	36.8	6.6%	1.4	-19.4%	1.7	-37.9%			
	1995	39.3		1.1		1.0				
Manufacturing (low skill)	1975	36.4	6.0%	1.4	-17.1%	1.9	-35.8%	-1.5	-0.7	0
	1995	38.6		1.2		1.2		-2.3		
Manufacturing (medium skill)	1975	38.0	6.3%	1.2	-18.5%	1.3	-42.1%	3.3	-0.2	1
	1995	40.4		1.0		0.8		3.1		
Manufacturing (high skill)	1975	37.0	9.2%	1.4	-32.7%	1.7	-53.0%	0.4	2.8	0
	1995	40.4		0.9		0.8		3.2		
Services (low skill)	1975	35.2	9.5%	1.7	-27.6%	2.2	-43.7%	-4.4	2.3	1
	1995	38.5		1.2		1.2		-2.1		
Services (medium skill)	1975	35.7	6.9%	1.6	-20.3%	2.0	-34.3%	-3.9	1.3	1
	1995	38.2		1.3		1.3		-2.6		
Services (high skill)	1975	35.4	8.0%	1.9	-32.3%	2.3	-43.3%	-4.6	2.2	1
	1995	38.2		1.3		1.3		-2.4		

Source: IAB Employment Sample, own calculations.

Figure 2 offers, again, a quick identification of relative ageing in the manufacturing sector. In Figure 2a data points for the three categories of manufacturing industries are located in different regions: medium- and high-tech are located North-East, low-tech South-West. This means that the employed were and remained older in the

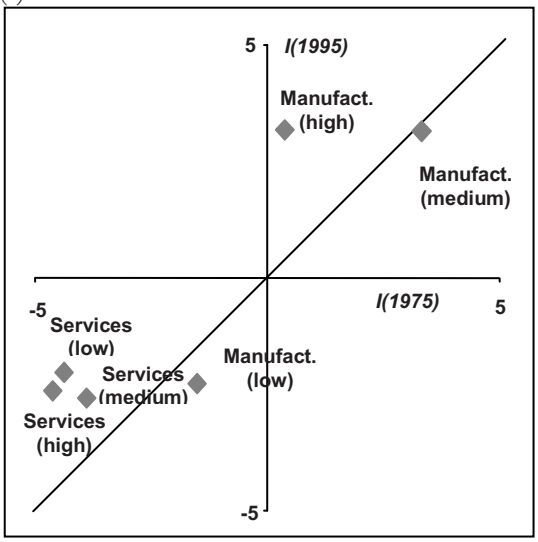
10 Subgroups add to 80.4 % of the reference group.

former two categories whilst they were and remained younger in the third group. Still, both low- and medium-tech industries (located below the 45°-line) experienced slower ageing than the reference group, whilst high-tech industries (located above the 45°-line) were marked by faster ageing. The Convergence-hypothesis 1 is thus contradicted in two out of three categories of manufacturing industries: Low-tech industries were relatively young at the beginning of the observation period, still they aged at a lower than average speed thus remaining, of course, younger to the end. In contrast to this, high-tech manufacturing industries were older than average in the beginning, yet they aged faster than average and hence remained older than average.

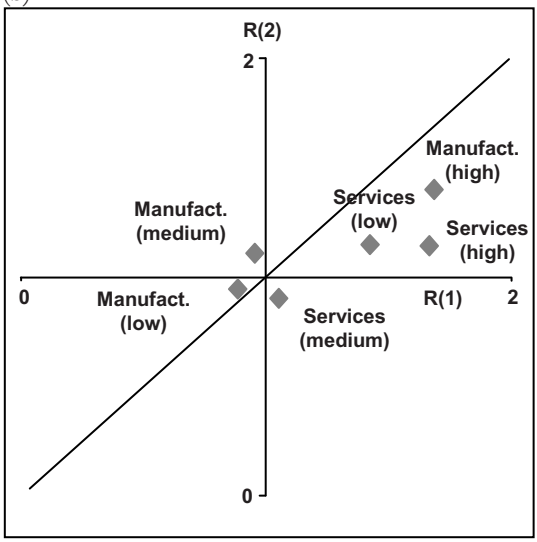
A look at Figure 2b reveals that in low- and medium-tech industries changes in the age composition were at an above average rate fed by changes at the margins of the age distribution. In high-tech industries developments were different: Here, changes in the age composition occurred at an above average rate from the middle of the age distribution, a tendency that intensified during observation time. Hypothesis 2 thus receives overall support.

Figure 2: Comparative dynamics of German sectors and industries (manufacturing and services) according to knowledge intensities, 1975–1995

(a)



(b)



Source: IAB Employment Sample, authors' illustrations.

3.2 Industry-Specific Age Structures

The picture of ageing processes becomes even more differentiated if we pass over to the level of single industries. All measures of ageing expose a large variation across industries (see Table 2 and Figure 3). Mean age is shown in column 1 in Table 2. In 1975, mean age in legal and economic consulting was 30.5 years and thereby lowest of all industries under observation; in 1995 the highest values we found were 42.4 years for civil servants and 41.7 in the education sector. Among private sectors it was highest in mining[11] and energy where it amounted to 41 years in 1975 and 1995, as well as in chemicals with 41.4 years in 1995. It looks as though industries are often economically and demographically old or young (new).[12] Thus, the sectors health, media, consultancy, financial intermediation surely belonged to the "new economy" in 1975, the chemical sector, metallurgy and education were already "old economy". The only industry that does not seem to fit the conjecture is

11 Given the huge amount of subsidies mining received we should maybe not really attribute it to the private sector.

12 See Bartel and Lichtenberg (1987) for a study of the importance of young and educated workers in new industries which are often associated with a higher rate of technical change.

agriculture[13]. The reason might be that it does not comprise what one expects at first sight, namely all agricultural workers; these are to a large extent self-employed, seasonal or not registered at all, as they work as family members. The data on paid labour force in agriculture rather catches physically exhausting activities (without career perspectives) that are best/only performed by the young.

However, mean age evolved very differently from industry to industry. On the one hand, in some former relatively "young" industries, like agriculture, mean age increased much less than in the reference group. Whereas on the other hand, trade and consultancy aged almost or more than twice as much, respectively. Still, all three industries remained (much) younger than the reference group. In order to get a better picture of the dynamics of the age composition, look at columns 2 and 3 of results in Table 2. The ratio *R(1)* decreases in all but two industries (agriculture/ mining and energy) showing that the labour force aged under 40 decreased as compared to those aged over 40. For example, if in consultancy on average four employees aged 40 and less worked with one aged over 40 in 1975, twenty years later the ratio was already two to one.

In contrast to this, the ratio *R(2)* indicating the proportion of age group under 30 to age group 50+ reveals that all industries aged from the margins of the age distribution. This is particularly true for machinery, wood, paper and printing as well as consultancy. Finally, the ageing index *I* in column four of Table 2 varies between minus 18.2 for consultancy (documenting heavy ageing) and plus 11.5 for mining and energy. Both are also at the extremes if it comes to changes in the age structure. Whereas mining and energy experienced only a minor drop in mean age and only slight changes in the ageing ratios, resulting in a falling index value, the consultancy branch grew considerable older (strong increase in mean age and clearly decreasing ratios resulting in a growing index value). All other industries have an index and document changes between these extreme values.

13 This low mean age in German agriculture is particularly interesting against the background of data from other ageing economies. Thus, the median age of workers in primary industries in 2000 was 63.4 years for Japan and 45.1 years in Australia (Orzechowksa-Fischer 2004).

Table 2: Changes in age composition of selected German industries, 1975-1995[14]

		Mean Age		Ratio 1		Ratio 2		Index		Hypothesis 1
			Change in %		Change in %		Change in %		Absolute change	
Average	1975	36.8	6.6%	1.4	-19.4%	1.7	-37.9%			
	1995	39.3		1.1		1.0				
Agriculture	1975	35.4	3.9%	1.3	33.0%	1.9	-8.3%	-2.6	-4.4	0
	1995	36.8		1.7		1.7		-7.0		
Minning, energy	1975	41.0	-0.1%	0.7	28.6%	0.7	-3.0%	11.5	-6.5	1
	1995	41.0		0.9		0.7		5.0		
Chemicals and chemical products	1975	39.5	4.7%	1.0	-13.4%	1.0	-36.6%	7.3	-1.7	1
	1995	41.4		0.8		0.6		5.6		
Basic metals and metal products	1975	38.8	5.1%	1.0	-11.6%	1.1	-35.6%	-1.0	2.6	1
	1995	40.8		0.9		0.7		1.6		
Machinery and equipment	1975	36.9	10.7%	1.4	-36.1%	1.6	-56.1%	0.1	3.9	0
	1995	40.8		0.9		0.7		4.0		
Automobile	1975	35.7	8.2%	1.5	-23.9%	1.9	-44.1%	0.5	2.0	0
	1995	38.7		1.1		1.1		2.6		
Electrical equipment	1975	37.0	8.2%	1.4	-28.5%	1.7	-49.9%	0.4	2.0	0
	1995	40.1		1.0		0.8		2.4		
Optical equipment	1975	35.9	5.8%	1.5	-9.3%	2.1	-34.4%	-2.9	-0.2	0
	1995	37.9		1.3		1.3		-3.1		

14 Subgroups add to 72.1 % of the Reference Group.

		Mean Age		Ratio 1		Ratio 2		Index		Hypothesis 1
			Change in %		Change in %		Change in %		Change in %	
Wood, paper, print	1975	37.5	4.0%	1.2	-2.9%	1.5	-29.1%	2.0	-2.9	1
	1995	39.0		1.2		1.1		-1.0		
Textiles, leather, clothing	1975	36.7	12.3%	1.3	-37.0%	1.7	-55.9%	-0.4	4.9	1
	1995	41.2		0.8		0.7		4.5		
Construction	1975	36.2	6.3%	1.5	-17.6%	2.1	-44.4%	-0.9	-1.7	0
	1995	38.5		1.2		1.2		-2.6		
Wholesale and retail trade	1975	35.0	11.0%	1.7	-32.2%	2.3	-49.2%	-5.1	3.9	1
	1995	38.8		1.2		1.2		-1.2		
Financial intermediation, insurances	1975	35.3	7.6%	1.9	-32.2%	2.3	-37.7%	-5.6	2.3	1
	1995	38.0		1.3		1.4		-3.3		
Schooling	1975	39.0	6.7%	1.2	-34.3%	1.0	-47.2%	6.0	0.7	0
	1995	41.7		0.8		0.5		6.6		
Media, culture, entertainment	1975	36.7	5.6%	1.5	-18.3%	1.7	-37.4%	-0.1	-0.4	0
	1995	38.8		1.2		1.1		-0.5		
Health	1975	34.2	6.9%	1.9	-15.9%	2.6	-26.5%	-8.5	1.7	1
	1995	36.6		1.6		1.9		-6.8		
Consultancy	1975	30.5	16.2%	3.9	-49.1%	5.7	-56.9%	-18.2	8.5	1
	1995	35.5		2.0		2.5		-9.7		
Technical consultancy	1975	34.4	12.2%	2.5	-46.6%	3.2	-65.7%	-6.2	5.2	1
	1995	38.6		1.4		1.1		-1.0		
Public administration	1975	41.4	2.4%	0.8	-9.1%	0.7	-24.2%	11.4	-3.1	1
	1995	42.4		0.7		0.5		8.2		

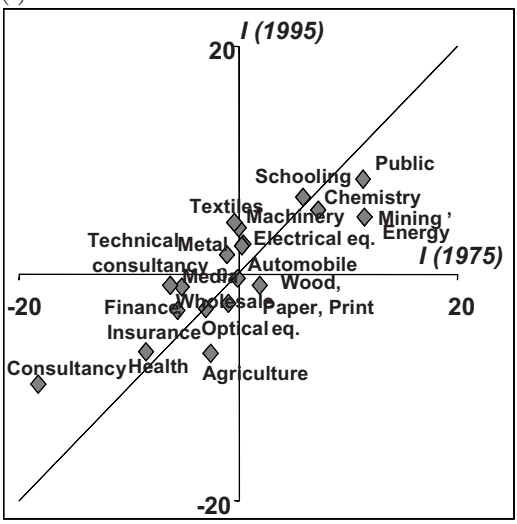
Source: IAB Employment sample, own calculations.

Figure 3 allows an overview of the dynamics of ageing across industries that Table 2 does not offer. From Figure 3a we get the impression that many industries with rather shrinking economic importance like agriculture, wood, paper, printing, construction, mining, energy age slower than the reference group whereas industries with a high economic weight in Germany like machinery, electrical, automobiles, metallurgy, health, financial intermediation and insurance, consultancy age at a pace above average. A good example is consultancy: It belonged to the "new" and demographically young economy in 1975; its economic importance increased, employment grew by 189 % in twenty years and employees aged with the industry. However, testing the implied or related hypothesis concerning economic importance and ageing of industries needs an analysis on lower aggregation levels. As such it remains one of our future directions of research.

Hypothesis 1 cannot be confirmed for single industries; it is formally violated by 8 out of 19 cases. Especially agriculture and parts of manufacturing show no tendency to converge. Comparing Figure 3a and 3b reveals that all industries we found to age relatively slowly in Figure 1a, display predominant ageing from the margins of the age distribution in Figure 3b, and vice versa, which confirms Hypothesis 2.

Figure 3: Comparative dynamics of selected German industries, 1975–1995

(a)



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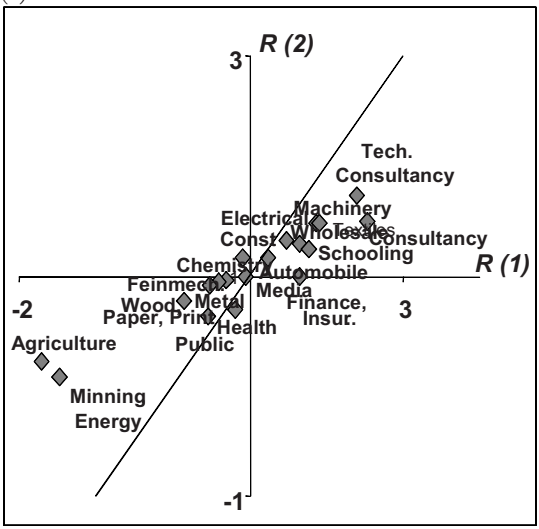

Source: IAB Employment Sample, authors' illustrations.

4. Summary and Conclusions

In this paper we performed a detailed analysis of the dynamics of ageing in German industries. To our knowledge, this is the first study of its kind. In order to compare the process of ageing in different subpopulations, we use different indicators such as the mean age, two ratios of younger and older workers and we finally construct an ageing index, which reveals information about deviations from the average changes. The introduction of different measures becomes necessary because ageing is a complex process and different indices have different assets and drawbacks.

The analysis of 19 industries partly confirmed two hypotheses we used as a starting point. The first one is that we have a convergence in the age structure when looking at different subpopulations of the labour force. This means: Starting with a comparable young group of workers in the past implies that ageing takes place at higher pace and the other way around. The reason for this can be that "new economy" firms employ a stock of workers in the beginning and then only gradually hire new workers. Hence, with no hiring a firm's mean age increases by one year per year, which would be much more than on average. Indeed, ageing in eleven industries occurs in this manner, whereas in eight Hypothesis 1 must be clearly refused. Our second hypothesis is that industries that are rapidly ageing do so because the

stock of middle-aged employees grows old. This is also a sign of a maturing industry. The hypothesis could be confirmed for all nine fast ageing industries.

However, the confirmation for our two hypotheses is only weak if we analyse manufacturing and services by knowledge intensity. Service industries were and remained younger but aged faster as compared with the reference group. Hence, there is convergence. It is also true that ageing was particularly driven from the middle of the age distribution. In contrast to this, ageing does not follow our hypotheses in manufacturing. Quite the contrary, low-tech industries were youngest, but aged slower and high-tech industries were older, but aged faster. However, Hypothesis 2, saying that fast ageing comes from the middle of the age distribution, holds true for manufacturing.

Further research on ageing differences in the labour force seems promising. A big gain from such studies is that they can help to forecast labour shortages in specific labour market segments. For example, the ratio R(2) can be seen as an early indicator of shortages in certain industries or occupations. Furthermore, if our two hypotheses can be further confirmed, we can learn much more about the development and maturing of industries and occupations.

Acknowledgement

This study uses the factually anonymous IAB Employment Sample (IABS) (Years 1975-1995). Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB).We wish to thank all participants and discussants at the 2nd European Workshop - Labour Markets and Demographic Change and at the annual DGD conference 2007 who provided us with extremely useful insights and new inputs.

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Unemployment by Age and the Unemployment Rate

Carsten Ochsen

1. Introduction

This paper examines the effects of shifts in the age group size of the unemployed on the unemployment rate. Since ageing of the labour force will fundamentally change the shares of younger and older people that supply labour in most of the industrialised countries, it seems to be important to analyse if shifts in the age structure will change the level of the unemployment rate. From unemployment statistics it is known that the unemployment rate for the age group 55 to 64 years is lower than the unemployment rates for the age group 16 to 24 years and the prime-age group (25 to 54 years) in most of the OECD countries.[1] Hence, there are age-specific differences. In addition, it is observed empirically that the average duration of unemployment increases with age while the quit rate decreases with increasing age.[2]

One way to estimate the effects of the age structure on unemployment is the shift-share approach. An example is Shimer (1998), who attributes changes in US unemployment to variations in the population shares of age groups with low and high age-specific unemployment rates. However, the results are driven by the age group-specific cohort sizes and do not provide information about age-related flow rates. In contrast to this Shimer (2001) estimates the impact of changes in the population share of the young (age 16 to 24) on unemployment in the US. In this case it is possible to draw conclusions about the relative flow rates for the young only. The contribution of this paper to the literature is twofold. First, our approach allows to draw conclusions about differences in age-dependent net flow rates on the labour market. In contrast to Shimer (1998) we can separate the flow effects from cohort effects and unlike Shimer (2001) we consider shifts in the age distribution of the unemployed instead of a single population share. Second, the empirical results are related to a set of 16 OECD countries and, hence, allows more general conclusions.

In Section 2 we provide an extension of the standard equilibrium unemployment model that allows for age-dependent job finding probabilities and quit rates.

1 See, for example, the OECD Employment Outlook.

2 See, for example, Burgess (1993), Pissarides and Wadsworth (1994), Coles and Smith (1996).

In Section 3 we apply different panel estimators on data for 16 OECD countries to test the implications of the theoretical model. The results provide the somewhat surprising evidence that the distribution of unemployment by age has a hump-shape effect on the unemployment rate. That is, the larger the share of prime-age (25 to 54 years) unemployed, the higher the unemployment rate.

2. The Model

The aim of this paper is to analyse how the distribution of unemployment by age affects the level of the unemployment rate. Put differently, we want to examine if age-dependent net flow rates on the labour market exist and, hence, affect the unemployment rate. Using a weighted summation of age-dependent unemployment rates is not suitable, because this would mix the flow rate differences with the cohort size differences. On this account we favour an approach that is solely conditional on aggregated labour supply. We extend the standard equilibrium unemployment model by age-dependent job finding probabilities and quit rates. In the standard approach for steady state unemployment stock flow models the equilibrium unemployment rate is a function of idiosyncratic shocks λ and the average job finding probability p

$$u = \frac{\lambda}{\lambda + p(\theta)} \tag{1}$$

The equilibrium in search and matching models usually depends on a measure of the tightness of the labour market defined as the ratio of vacancies to unemployed $\theta = V/U$. The probability p depends on the labour market tightness θ because it determines how successful search is. It is easy to see that the probability $p(\theta)$ can be interpreted as a weighted average with weights, for example, given by the distribution of unemployment by age.

This follows directly from

$$pu = p\left(\frac{U_1}{L} + \frac{U_2}{L} + \ldots + \frac{U_n}{L}\right) = p\sum_i \frac{u_i}{u} u = p\sum_i s_i u \,. \tag{2}$$

U_i (with $i = 1, 2, \ldots n$) is the age-related number of unemployed and L is the labour force. The term $s_i = U_i/U = u_i/u$ is the age-dependent share of all unemployed. Equation (2) points out that the assumption of a constant $p(\theta)$ for a given θ is a special case of a more general approach in which different age-specific reemployment

probabilities are considered. Hence, according to this equation the level of the unemployment rate depends on the differences in age-related reemployment probabilities for a given number of unemployed.

Similar to the average job finding probability, the average idiosyncratic shock in equation (1) can be interpreted as a weighted average with weights given by the distribution of unemployment by age:

$$\lambda = \sum_i \lambda_i s_i$$

In the empirical part of the paper we distinguish between three different age groups only, due to data availability. Hence, for a model with young *(Y)*, prime-age (*P*) and old (*O*) unemployed, a steady state equilibrium unemployment is given by

$$u = \frac{\lambda_Y s_Y + \lambda_P s_P + \lambda_O s_O}{\lambda_Y s_Y + \lambda_P s_P + \lambda_O s_O + p_Y(\theta) s_Y + p_P(\theta) s_P + p_O(\theta) s_O} . \qquad (3)$$

While λ_i shifts the Beveridge curve outwards, p_i shifts the curve inwards. For s_i the effects are ambiguous. Simply, because if one of the shares changes, at least one of the others change too. In addition, it is ambiguous if the net effect of inflow minus outflow for a specific share is above or below the average net value. Equation (3) includes age-related job finding probabilities and quit rates that are not weighted by the corresponding labour force size. This allows us to compare the age-related net flow rates directly. This is an important difference to the shift-share approach mentioned above, for which we are not able to distinguish between flow and cohort effects.

3. Empirical Analysis

In this section we investigate empirically the relation between the unemployment rate and the distribution of unemployment by age. In order to provide a first cross-country evidence for our data we calculate correlation coefficients for all countries considered in this paper. Table 1 provides the correlation coefficients for the unemployment rate and the unemployment shares of the age groups young (16 to 24 years), prime-age (25 to 54 years) and old (55 to 64 years). The coefficients refer to 16 OECD countries and the period 1975 to 2000.

The unemployment rate is negatively related to the share of young and old unemployed, but the correlation between the share of prime-age unemployed and the unemployment rate is almost zero. This means that the net flow rates for the young and the old yield a lower unemployment rate. Remember that age group-related

unemployment rates may yield a different pattern if the corresponding labour force sizes have large differences. The correlations between the shares reveal the shifts in the cohort size due to the demographic change.

Table 1: Correlation Coefficients: Age Groups

	s_Y	s_P	s_O
s_P	-0.908		
s_O	-0.543	0.141	
u	-0.213	0.029	-0.562

Notes: s_Y: share of young unemployed (15 to 24 years); s_P: share of prime-age unemployed (25 to 54 years); s_O: share of old unemployed (55 to 64 years); u: unemployment rate.

The data for the standardised unemployment rate (*u*) and unemployment by age is taken from the OECD online database. Unemployment by age is subdivided into young unemployed (16 to 24 years old), prime-age unemployed (25 to 54 years old), and old unemployed (55 to 64 years old). The corresponding shares have a range of 0 to 1. To get reliable estimates we consider a set of institutional and macroeconomic control variables that are taken from Nickell and Nunciata (2002).[3]

With respect to the countries considered only those are accounted for who provide data for the age groups at least for ten years: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom and the USA. The period is 1975 to 1995 due to data availability.

We now analyse econometrically whether the distribution of unemployment by age has an effect on the level of the unemployment rate. In the estimates only two of the three shares can be included, since they sum up to one. We therefore estimate all three possible combinations. This allows to interpret the share effects more specifically, since the estimated effects are always on account of the excluded share. We argue that significantly different estimates for the shares correspond to significantly different net flow rates.

The following equation will be estimated:

3 Institutional control variables are: Benefit replacement rate, benefit duration, employment protection, year to year changes in net union density and coordination of bargaining. Macroeconomic control variables are: Terms of Trade shocks, labour demand shocks, total factor productivity, real interest rate and vacancy rate.

$$\log(u_{it}) = \beta_0 + \beta_1 s_{jit} + \beta_2 s_{kit} + \sum_m \phi_m X_{mit} + \alpha_i + \gamma_t + \varepsilon_{it} .$$

s_j and s_k are two of the three duration groups (s_j , s_k , s_O) and a_i and γ_t are fixed cross-country and time effects, respectively, and X is a vector of m control variables. We consider two additional specifications to account in a different way for unobserved heterogeneity. First, instead of time effects we consider a time trend and country-specific first order autoregressive terms. Second, we do the same but now with country-specific time trends instead of the aggregated time trend. White robust covariances are used to control for cross-equation correlation and different error variances in each cross-section unit.

Table 2: Main regression results

	1	2	3	4	5	6	7	8	9
s_Y	1.55	-0.59		-0.95	-2.15‡		-0.69	-2.37‡	
	(1.12)	(0.52)		(0.68)	(0.38)		(0.77)	(0.30)	
s_P	2.14†		0.59	1.19#		2.15‡	1.68†		2.37‡
	(1.01)		(0.52)	(0.63)		(0.38)	(0.71)		(0.30)
s_O		-2.14†	-1.55		-1.19#	0.95		-1.68†	0.69
		(1.01)	(1.12)		(0.63)	(0.68)		(0.71)	(0.77)
R^2	0.90	0.90	0.90	0.97	0.97	0.97	0.98	0.98	0.98
fe	✓	✓	✓	✓	✓	✓	✓	✓	✓
te	✓	✓	✓						
at				✓	✓	✓			
ct							✓	✓	✓
ar				✓	✓	✓	✓	✓	✓
n	286	286	286	270	270	270	270	270	270

Notes: dependent variable: log of unemployment rate; s_Y: share of young unemployed; s_p: share of prime-age unemployed; sO: share of old unemployed; fe: fixed effects; te: time effects; at: aggregated time trend; ct: country time trend; ar: first order autoregressive term; n: observations; ‡, †, #: significant at the 1%-level, 5%-level, 10%-level; robust standard error in parenthesis.

Table 2 displays the main results.[4] Regressions 1 to 3 are specified as standard-fixed effects models. The results are in line with the correlation pattern between the shares and the unemployment rate in Table 1. That is, the larger the shares of young and old unemployed the lower the overall unemployment rate. However, the effect is significant only for the share of the old. Regressions 4 to 6 and 7 to 9 have different specifications with respect to unobserved heterogeneity. According to these results the unemployment rate increases significantly with the share of prime-age unemployed. In addition, we find no statistically significant difference between the net flows of the young and the old. The results provide evidence that the distribution of unemployment by age has a hump-shape effect on the unemployment rate. That is, although the average duration of unemployment increases with age, the overall effect for the age group 55 to 64 years is lower than the effect of the prime-age group (25 to 54 years).

This can be explained by a simple relation. Any given level of aggregated unemployment can arise from a certain number of persons unemployed for a short period of time or a smaller number of unemployed for a long period. Given that the age group 55 to 64 years has the least job finding probability, the inflow rate for the prime-age group must be larger than the corresponding rate for the old unemployed. The surprising part in this result is that this difference has a stronger impact on the unemployment rate than the difference between the age-dependent duration of unemployment.

4. Conclusions

This paper examines the effects of shifts in the age group size of the unemployed on the level of unemployment. The results provide evidence that the distribution of unemployment by age has a hump-shape effect on the unemployment rate. This can be explained by differences in net flow rates. That is, the larger the share of prime-age (25 to 54 years) unemployed, the higher the unemployment rate. This is surprising if one takes the different pattern of age-related unemployment rates into account. With respect to the ongoing demographic change this is an important result. Provided that the share of people 25 to 54 years on the labour market decreases for the benefit of older worker (55 to 64 years) in the future, ageing on the labour market reduces the unemployment rate, if these effects are not related to birth cohorts (baby boomer or not baby boomer) and age-related labour market participation rates do not change noticeably.

4 Complete results will be provided upon request.

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II. Age Structure & Productivity at Firm Level

Absenteeism in Age-Diverse Work Teams

Matthias Weiss[1]

1 Introduction

Age-diverse work teams are being advocated as an important management tool to enhance performance and productively employ older workers. However, this advice is not founded on empirical evidence. There are very few studies that look at the relation between performance and age diversity of work teams. This lack of evidence is mainly due to a lack of available data. Information on performance and worker composition of a productive unit is available almost exclusively on the plant level in matched employer-employee data sets. But on the plant level, age heterogeneity of the workforce does not tell much about age diversity on the level where cooperation/teamwork takes place (work teams, departments, etc.). If all of the older workers work in the administration whereas all the young employees work in the production, the firm's workforce may be highly age-diverse, but work teams and departments are age-homogeneous. This problem notwithstanding, Grund and Westergård-Nielsen (2005) look at the relation between productivity and the standard deviation of workers' age in a sample of 7,000 Danish firms. They find a hump-shaped relation.

Leonard and Levine (2003), Hamilton, Nickerson and Owan (2004) and Börsch-Supan, Düzgün and Weiss (2007) study the productivity of work teams. They all find a negative relation to age diversity.

Absenteeism due to sickness is an important detriment to productivity: After all, when persons are absent from work their productivity on that particular day is zero.[2] Absences can lead to a substantial loss of actual working time and thereby

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2 Absenteeism can be seen as the extensive margin of productivity whereas the productivity of those present is the intensive margin.

impose substantial costs on both, firms and co-workers. Therefore – in the presence of ubiquitous calls for age diversity – it is important to study the relation between age diversity and sick leave.

The literature on absenteeism consists of two strands: One is concerned with the effects of individual characteristics of workers (gender, age, wage, education, health status, marital status, number of children) on their absenteeism. The other strand considers the role of the work environment (work conditions and risks, sick pay arrangements, control mechanisms, firm size, contracts) and the incentives the workers face (e.g., variations in absenteeism in different phases of the business cycle).

What has — to the best of my knowledge — not been studied yet is the link between team composition and absenteeism. There is literature in psychology that finds a negative relation between workers' job satisfaction and motivation to their absenteeism (see, e.g., Steers et al. 1978, Farrell et al. 1988, Scott et al. 1985 and Kohler et al. 1993). Other studies, in turn, find that job satisfaction is affected by team-mates' characteristics (Spector 1997).

In this paper, I study absenteeism using a unique data set of workers in a German truck assembly plant where I can identify workers who work together in a team on a daily basis. Thus, I am able to relate the probability of absence of a worker to characteristics of the work team. Characteristics of the work team in this study include team size and measures of diversity with respect to age, nationality, education and age.

It should be noted at this point that – even though "sickness" is reported as the reason for absence in the data set – other factors like motivation and pressure certainly have an effect (Steers et al. 1978). The "decision" to call in sick is the result of a process that is influenced by all three factors: Health, motivation and pressure/control. If motivation and pressure/control are weak, "less sickness is needed" to actually call in sick. In addition, motivation (job satisfaction, etc.) and pressure can affect workers' health and thereby indirectly affect absenteeism.

2 The Data

In this section, I give a brief description of the data set that is used in this paper. I use data from a truck assembly plant of a German car manufacturer. At this plant, trucks are assembled by work teams on a production line. The assembly line is split into 50 workplaces at which work teams of five to fifteen workers work together. I have information on the daily composition of these work teams on any workday in 2003 through 2005 and on personal characteristics of the workers such as age, gender, education, nationality and job tenure. In addition, the data set contains information about whether or not a worker is in her regular team.

Absence Rates The average rate of absence due to sickness is 5.5%[3]. There is variation over time and across workers as can be seen from Figure 1.

The daily absence rate is defined as the percentage of workers on a given day who are absent due to sickness. The distribution of the daily absence rate is given in the left part of Figure 1. The individual absence rate is defined as the percentage of days on which an individual has been absent. The distribution of individual absence rates is given in the right part of Figure 1.

Absence rates also vary quite substantially across age groups. On average, absence due to sickness increases with age (see the left panel of Figure 2). The next section will reveal whether this relation still holds in a multivariate setting. The right panel of Figure 2 shows that absence rates also vary substantially within age groups.

3 In the remainder of the paper, I refer to absence due to sickness whenever I use the terms "absence", "sick leave", or "sick days".

Figure 1: Distribution of absence rates due to sickness over time and across workers

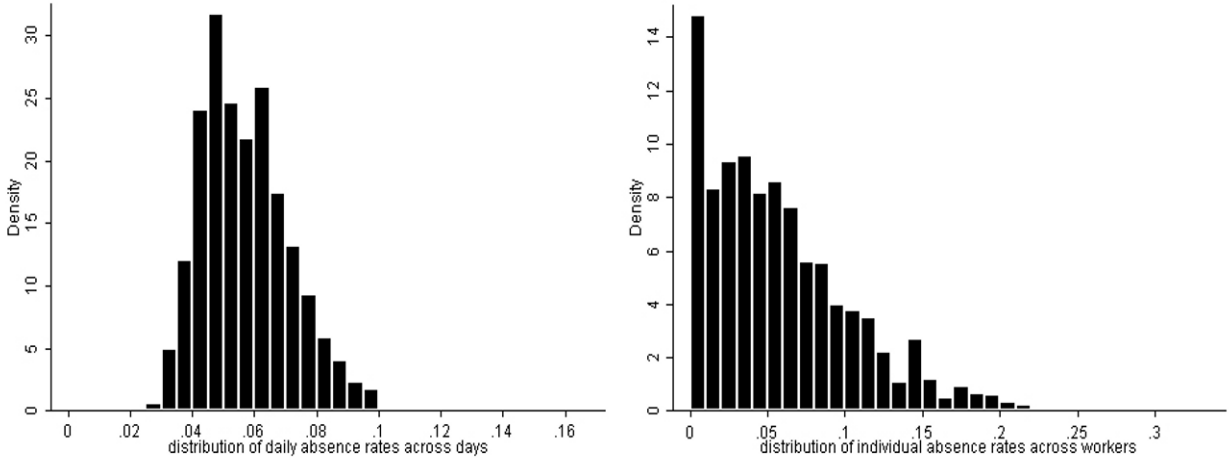
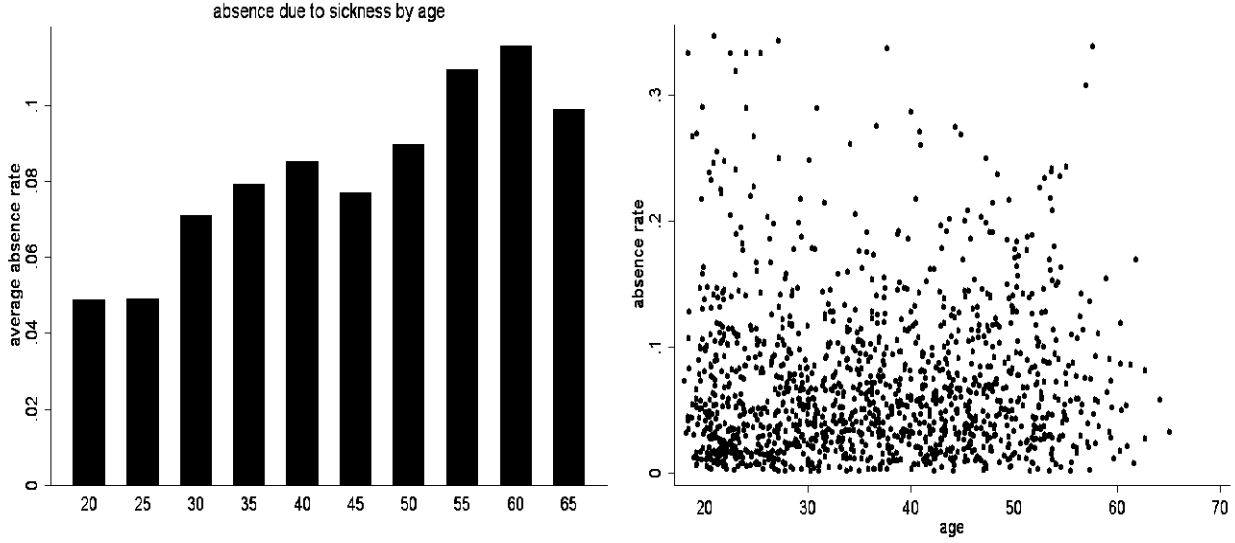


Figure 2: Average absence rates due to sickness by age group and individual absence rates vs. individual age



Age The age composition in the plant is fairly representative for the German workforce: Workers older than 55 are rare. Figure 3 shows the age distribution in the plant (black) in comparison to the age distribution of the whole population (grey). People younger than twenty are underrepresented, because they are still in education or training. The share of workers aged 55 and over is low, because many are already retired. Figure 4 shows the distribution of the average age of work teams.

Figure 3: Age distribution in the plant (black) and in Germany (grey)

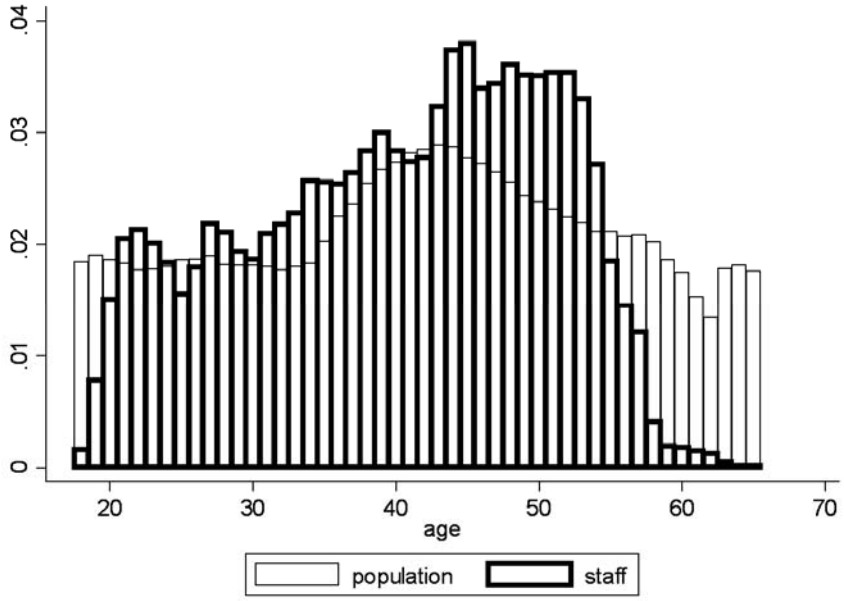
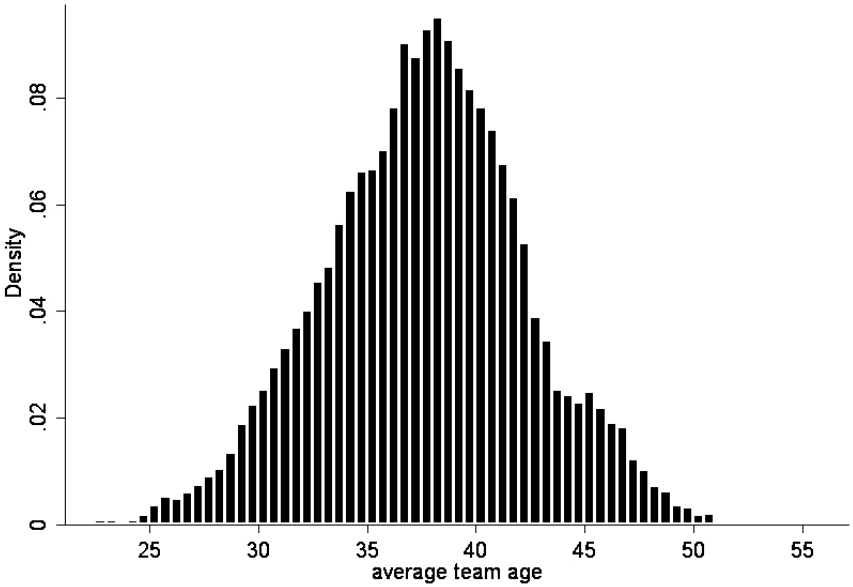


Figure 4: Distribution of average age of work teams.



Job Tenure In addition to age, I have information on workers' job tenure. Job tenure increases with age, but the two variables are not perfectly correlated across workers as workers are hired at different ages. The distribution of individual job tenure in the plant is shown in the left panel of Figure 5. The peaks show hiring waves roughly every five to ten years, the most recent having been just within the observation period (at job tenure=0). The distribution of average job tenure in work teams in the right panel of Figure 5 shows that at hiring waves, the new workers must have been spread evenly over existing work teams as the histogram in Figure 5 does not exhibit any comparable peaks.

Figure 5: Distribution of job tenure in the plant: Individual (left panel) and work team average (right panel)

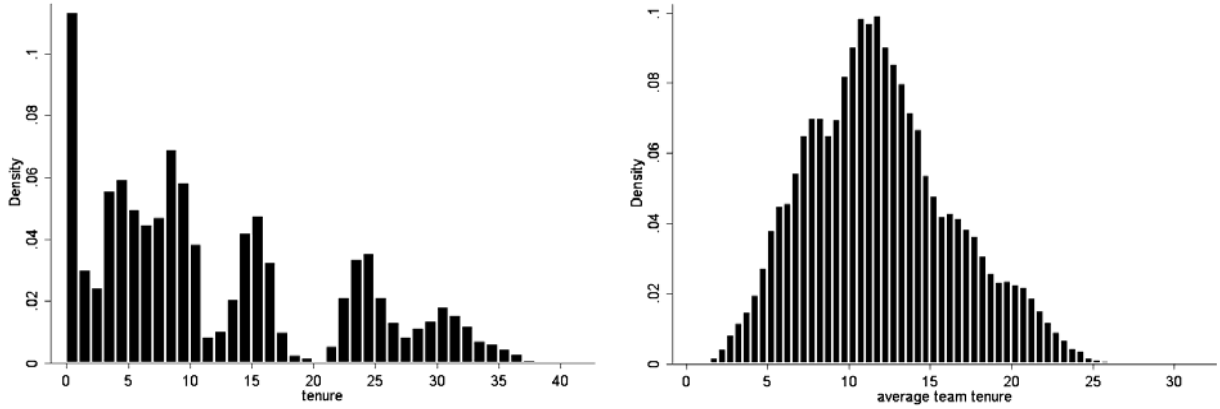
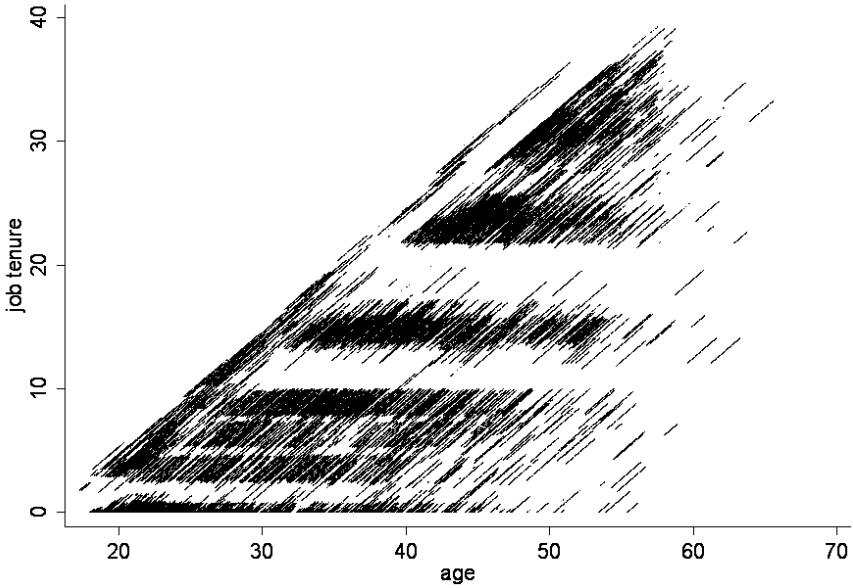


Figure 6 shows the relation between age and job tenure in the plant. For any individual worker, age and job tenure are perfectly correlated over time, but as workers are hired at different ages the overall correlation (over time and across workers) is "only" 0.79.

Figure 6: Scatter plot of job tenure (vertical axis) vs. age (horizontal axis).



Sex, Nationality, Education The overall share of women in the plant is 3.7%. 67% of all work teams are composed of men, only. In the other 33% of teams women's share is about 11%.

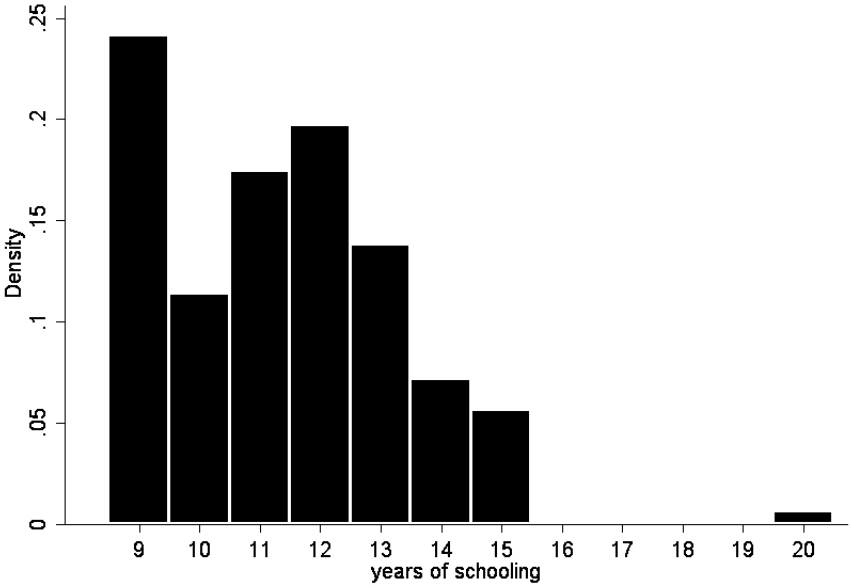
The composition of the personnel with respect to nationality is given in the following table:

Table 1: Share of the personnel by nationality

nationality	German	French	Turkish	other
share	67.0%	24.5%	3.8%	4.7%

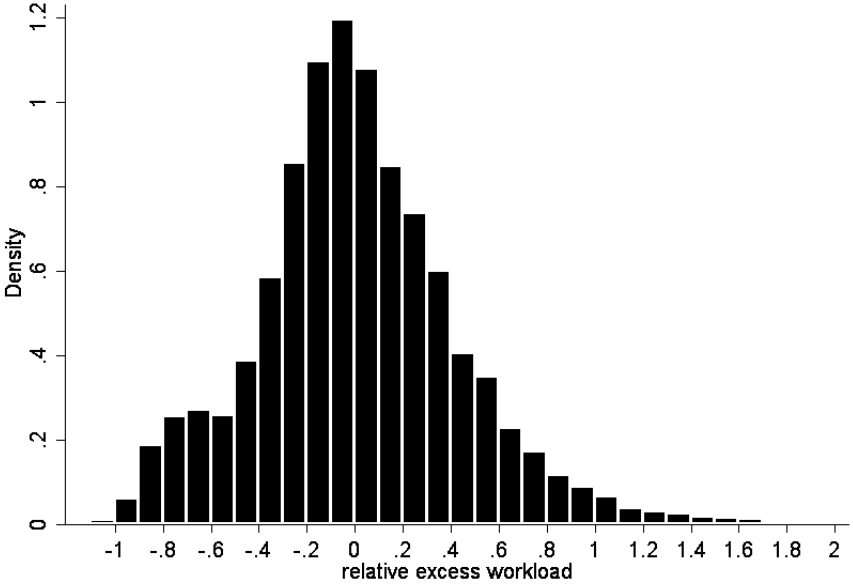
I also have information on the education of the workers. As a first step, I just calculated the total number of years of schooling for each worker. The distribution is shown in Figure 7. Most workers go to school for nine years. Many of them complete an apprenticeship right afterwards. I count this as "schooling" as well, because in Germany apprenticeships are very structured and 50% of their time apprentices actually go to (vocational) school.

Figure 7: Distribution of schooling years



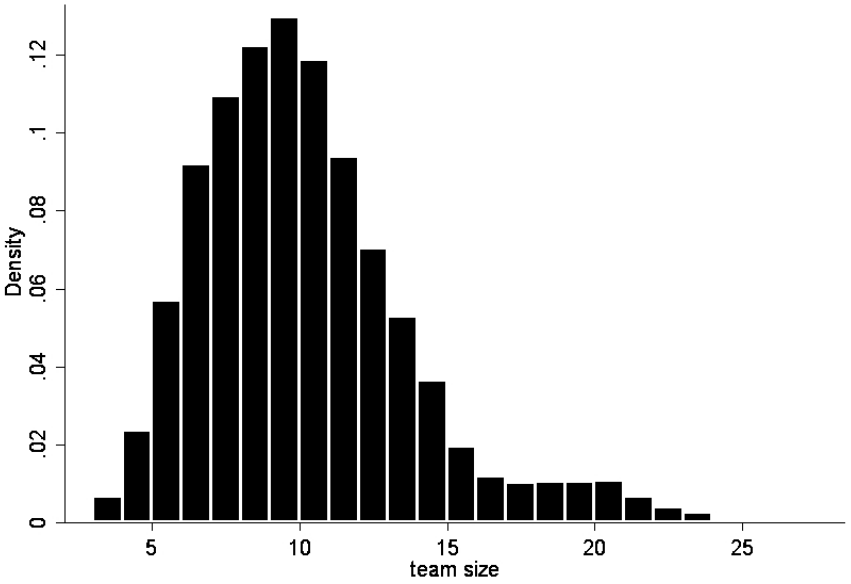
Work Load The production program and thereby the daily volume of work for every team varies over time. The required number of workers does not always exactly match the actual manning. I have daily information on the actual volume of work (measured in workers) and the actual manning for every day and every team. I use the percentage deviation of the actual volume of work from actual manning as a measure of excess workload per worker. Figure 8 shows that the variation in excess workload is substantial.

Figure 8: Distribution of excess work load (as a share of actual manning)



Team Size The size of work teams varies between 3 and 28 workers as it is shown in Figure 9.

Figure 9: Distribution of team size in the plant

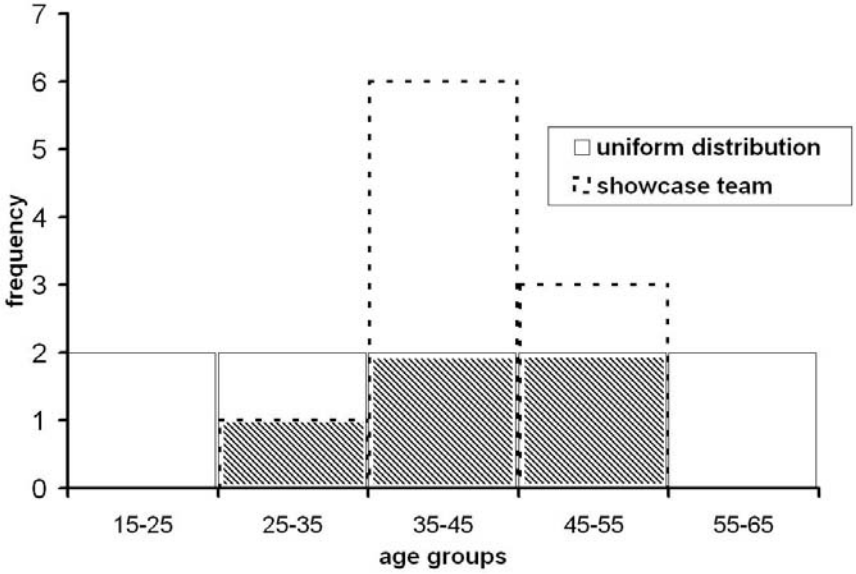


Age Diversity Results from medicine, psychology and gerontology teach us that younger workers are physically and mentally fitter while we expect older workers to be more experienced. These different qualities of workers with different ages suggest that good performance requires a well-balanced mix of younger (supposedly fitter, more flexible) workers and older (supposedly more experienced) workers. On the other hand, more diversity may impede communication and group cohesion (Leonard et al. 2003). This may adversely affect productivity and absenteeism. If communication and group cohesion are interfered, job satisfaction may in turn affect health and absenteeism.

In order to study the relation between age diversity and absenteeism, I have to construct a measure of age diversity. My interpretation of the complementary-argument is that having workers of each age in similar shares is good. In other words: the closer the age distribution is to uniformity, the better. The diversity variable thus measures how close the actual age distributions in work teams are to

uniformity. There are several ways to do this. My preferred approach calculates the surface area overlap of the actual age histograms of work teams with the "ideal" uniformity histogram. Figure 10 illustrates this for the showcase team with an age distribution given by the thin dotted histogram (one worker aged 25 to 35 years, six workers age 35 to 45 years, three workers aged 45 to 55 years). In terms of the complementarity argument, the ideal team would have an age distribution of two workers of each category. This is given by the histogram with continuous line. Our measure of how close the showcase team is to the "ideal" team is given by the surface area overlap (the hatched area in the figure). The larger this area is the more age diverse is the work team.[4]

Figure 10: Illustration of the diversity measure



4 Note that the concept of diversity is different from the concept of variance. While a small variance coincides with low diversity, a very large variance would mean that in the team are some very young workers and some "very old" workers and no workers aged 25 to 55. Such a team would have rather low diversity according to our measure as only two out of five age groups would be represented in the team.

More specifically, the hatched area for team j is given by:

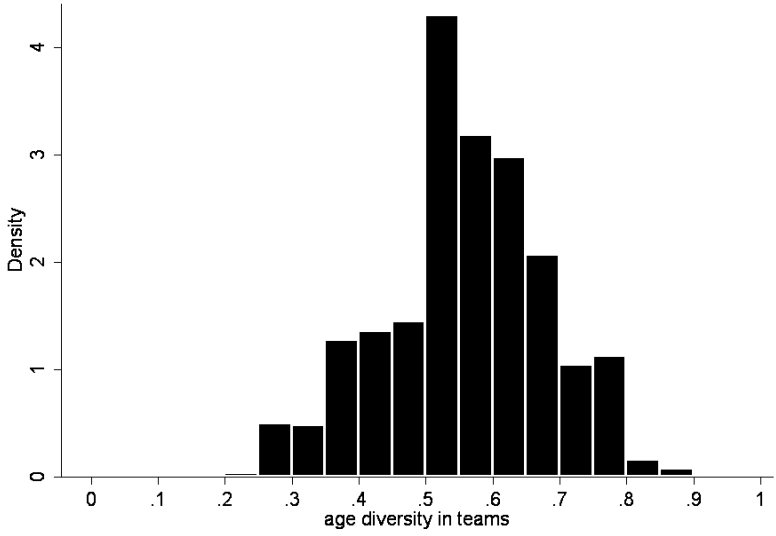
$$area_j = \sum_{i=1}^{k} min\left(\frac{x_{ij}}{N_j}, \frac{1}{k}\right)$$

where k is the number of age categories, xij is the number of workers in team j that belong to age category i, $Nj = \sum_{i=1}^{k} x_{ij}$ is the team size, xij/Nj is the relative frequency of age i workers in team j, i.e., the height of the age i--bar in the histogram. Area j is between $1/k$ (if all workers in team j belong to the same age category) and 1 (if team j has an uniform age distribution). In order for this diversity measure to lie within the unit interval independently of k, we normalise it to get:

$$diversity^{\,normalised} = \frac{\sum_{i=1}^{k} min\left(\frac{xij}{Nj}, \frac{1}{k}\right) - \frac{1}{k}}{1 - \frac{1}{k}} = \frac{\sum_{i=1}^{k} min\left(\frac{k * xij}{Nj}, 1\right)}{k - 1} \qquad (1)$$

Figure 11 shows the distribution of this diversity measure in our sample.

Figure 11: Distribution of age diversity



3 Results

I use day-to-day variation across 2,271 workers during 2003 and 2005 (730 work days) to estimate the effects of individual and team characteristics on absence due to sickness using a Logit specification. In order to avoid endogeneity problems that may arise, because managers form teams in order to minimise absenteeism, I control for work team-fixed effects. The results are reported in Table 2.

Age Absenteeism increases with age up to the age group of 35 to 40 years, only. For some older age groups absenteeism is even lower.

Job Tenure The effect of job tenure is less clear. There is no monotonous relation and the results are not very robust. This may reflect counteracting effects: A longer job tenure is usually associated with stronger identification with the employer, more responsibility (Baumgartel et al. 1959) and more interesting tasks (Nicholson et al. 1977). These factors should decrease absenteeism. On the other hand, longer job tenure also often implies better job security and — maybe — more boredom/less enthusiasm. These factors would lead to more absenteeism. The combination of these positive and negative effects may lead to the overall mixed results.

Education The effect of years of schooling on absence is u-shaped. Absenteeism is lowest among workers with 13 to 14 years of schooling. These are usually workers with a medium school degree and vocational training. As most tasks at the assembly line do not require higher education, better skilled workers may well be overqualified which reduces job satisfaction. Job satisfaction has been found to be an important factor for absenteeism (Steers et al. 1978). Workers with lower education may be assigned less responsible or less interesting tasks, so that their job satisfaction also suffers.

Diversity The main contribution of this paper is to study the relation of absenteeism to variables of team diversity. Age diversity in the work team increases the probability of calling in sick. This result calls into question the currently ubiquitous call for age-diverse teams. An explanation for this result might be that age diversity impedes communication and leads to lower group cohesiveness. This in turn can affect job satisfaction and the motivation to show up at work (Steers et al. 1978). In addition it can adversely affect workers' health.

Diversity with respect to job tenure clearly reduces absenteeism. Diversity with respect to job tenure facilitates the assignment of tasks and roles within a team so that conflicts and rivalry are avoided. This conflict-alleviating effect may lead to lower absenteeism.

Table 2: Regression Results

Dependent variable: absence due to sickness (dummy, logit specification)					
Age groups			Job tenure groups		
20 - 25 years	0.027	-0.021	5 - 10 years	0.034	(0.0079)***
25 - 30 years	0.09	(0.021)***	10 - 15 years	-0.017	(0.0101)*
30 - 35 years	0.087	(0.021)***	15 - 20 years	0.079	(0.0110)***
35 - 40 years	0.121	(0.021)***	20 - 25 years	-0.009	-0.0121
40- 45 years	0.089	(0.022)***	25 - 30 years	0.003	-0.0135
45 - 50 years	0.141	(0.022)***	30 - 35 years	0.065	(0.0149)***
50 - 55 years	0.155	(0.023)***	35 - 40 years	0.153	(0.0275)***
55 - 60 years	0.098	(0.026)***			
60 - 65 years	0.108	(0.033)***			
Age diversity	0.11	(0.023)***	Tenure diversity	-0.312	(0.0275)***
Years of schooling					
11 - 12 years	0.0041	-0.0066	Female	0.066	(0.015)***
13 - 14 years	-0.0276	(0.0075)***	Female share	-0.689	(0.049)***
15 - 20 years	-0.0004	-0.0102	External	-0.56	(0.015)***
sch. diversity	-0.298	(0.0294)***	External share	0.98	(0.030)***
Team size	-0.0433	(0.0030)***	Diversity w.r.t	0.024	-0.02
(team size)²	0.002	(0.0001)***	nationality		
Pseudo R²	0.0191				

observations: 687,548, unbalanced panel of 2271 workers in 100 work teams on 730 days.
Reference category for age groups: 15 - 20 years, reference category for job tenure: 0 - 5.
years, reference category for schooling years: 9 - 10 years. Standard errors in brackets.
*, ** respectively *** denote significance at the 10%, 5%, respectively 1% level. Further.
control variables: nationality dummies, weekday dummies, and a quadratic time trend.

Diversity with respect to education leads to lower absenteeism. The reason for this effect may be similar to the one for diversity with respect to job tenure. Diversity with respect to nationality does not have a significant effect.

Gender Women are more likely to be sick. In contrast, a higher female share in work teams enhances the attendance of team members. This is interesting, because the absence-reducing external effect of a higher female share neutralises (even slightly overcompensates) the effect that women themselves are more often absent due to illness.

External Workers Each worker is assigned to one team as her "regular" team. But – due to fluctuations in team composition as a result of sick leave or vacation or variation in workload – workers work on average 6% of the time outside their regular team. Being external to the team reduces the probability of sick leave. However, the share of externals in the team increases sick days.

Team Size Team size has a u-shaped effect on absence. The optimal team size is eleven workers. Similar results have also been found in other studies. If work teams are too large, group cohesiveness is low, task specialisation is high and communication is poor (Indik 1965 and Porter et al. 1965). If teams are too small personal conflicts may be more severe.

4 Conclusion

This paper contributes to the large literature on absenteeism and to the so far very smallliterature on the productivity of age-diverse work teams. Age-diverse work teams are being advocated as an important management tool to enhance performance and productively employ older workers. The idea is that good performance requires a well-balanced mix of younger (supposedly fitter, more flexible) workers and older (supposedly more experienced) workers. On the other hand, more diversity may impede communication and group cohesion (Leonard et al. 2003). This may adversely affect productivity (at both margins). If communication and group cohesion are interfered, job satisfaction and possibly also workers' health may suffer. Job satisfaction may in turn affect health and absenteeism.

The results of this paper suggest adverse effects of age diversity on productivity: Workers are more likely to call in sick when they work in more age-diverse work teams.

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Firm Productivity, Workforce Age and Vocational Training in Austria[1]

Bernhard Mahlberg, Inga Freund, Alexia Prskawetz

1. Introduction

The employment rate of older people in Austria is amongst the lowest within the EU countries. According to recent data by EUROSTAT, labour force participation of employees aged 55 to 64 in 2005 is 31.8% in Austria compared to an EU-15 average of 44.1%. An expected strengthening of this development is due to the shrinking and ageing of the overall Austrian working population during the next decades. On the firm level the ageing of the baby boom generation will put high pressure on human resource management, in particular so in a situation where disincentives for work at older ages and for hiring old workers prevail.

Although an ageing workforce as a whole is often associated with lower productivity, there are no clear-cut empirical findings to support this assumption, since the aggregate effects of ageing in combination with rising levels of education among younger workers are highly uncertain. In recent years, several approaches have been followed to estimate age-productivity profiles ranging from age-earnings profiles, supervisors' ratings and work-sample tests to matched employer-employee data sets. Strategies of encouraging older workers to remain longer in the workforce on the one hand and encouraging firms to hire old workers on the other hand as well as raising the effective retirement age need to be evaluated with regard to the productivity profile of older workers.

Based on a newly-created matched employer-employee data set for Austria in 2001, we estimate the impact of the employees' age composition on the firm's value-added controlling for training intensity at the firm level. The main challenge is

1 The project has been funded by the Oesterreichische Nationalbank under contract number OeNB11621. The authors are grateful to the participants of the North American Productivity Workshop 2006 in New York City, of the Annual Meeting of the German Demographic Association (DGD) 2007 in Berlin, of the '2nd European Workshop on Labour Markets and Demographic Change' 2007 in Rostock and of the conference 'Labor Market Flows, Productivity and Wage Dynamics: Ideas and Results from Empirical Research on Employer-Employee Linked Longitudinal Databases' 2007 in Moncalieri (Torino) for valuable comments and suggestions on first results of this study. Moreover, we would like to thank Statistics Austria for providing the data.

to isolate the effect of the employees' age from further influences on a company's productivity, whereby we are particularly interested in the firm's training intensity, which leads to strong identifying assumptions. Moreover, as our data is restricted to a cross-section in 2001, this only allows us to control for observed heterogeneity across firms. Thus, we are not able to handle the potential correlation between the share of older workers and the unobserved lagged level of firm productivity properly to account for reverse causality. We capture firms' heterogeneity by including firm-specific characteristics in our regressions. Since labour is not only heterogeneous with respect to age we also control for the educational, occupational and gender-specific structure of the workforce. Unfortunately, our data does not include any information on hours worked. Thus it only allows us to control for the share of part-time and full-time employees within a firm.

The paper is organised as follows: We present the empirical model in Section 2 and review the data in Section 3. Results are summarised in Section 4 followed by some robustness checks in Section 5. The final Section 6 concludes and provides an outlook for further research.

2. Derivation of the Empirical Model

Similar to Crépon et al. (2002) and Prskawetz et al. (2007), we assume perfect substitutability of workers of different types $k = 0,...K$.[2] The total amount of human capital, L^*, can be written as:

$$L^* = \sum_0^K \lambda_k L_k = \lambda_0 L + \sum_1^K (\lambda_k - \lambda_0) L_k = L\lambda_0 (1 + \sum_1^K (\frac{\lambda_k}{\lambda_0} - 1)\frac{L_k}{L}) = L\lambda_0 (1 + \sum_1^K \gamma_k W_k), \qquad (1)$$

where L is the sum of the labour input, λ_0 is the productivity of the workers taken as the reference category, $(L_k/L)=W_k$ denotes the share of workers of type k and γ_k is equal to (λ_k/λ_0-1). Applying the approximation $log(1+x)\sim x$ we can write (1) as:[3]

$$log(L^*) = log(L) + log(\lambda_0) + log(1 + \sum_1^K \gamma_k W_k) = log(L) + log(\lambda_0) + \sum_1^K \gamma_k W_k \qquad (2)$$

2 Marginal productivities may differ among the different types of employees.

3 This approximation will be valid as long as x is rather small. In our case the approximation may be rather crude (since x represents the sum of share variables). We follow the convention in the literature and apply the approximation that facilitates the application of a linear regression.

We are further following Crépon et al. (2002: 7 ff.) by introducing an approach that they term the 'simple model' in order to reduce the number of categories.[4] Owing to the lack of appropriate data on the capital stock[5] at the firm level, we restrict our analysis to labour productivity defined as value added per employee at the firm level denoted by v_i where i indicates the firm. We then estimate a multivariate linear model[6] in which we regress log value added per employee on the log level of human capital as defined in equation (2) and additional firm-specific characteristics X_i to account for firm heterogeneity. Our estimated equation for the production function in the simple model is

$$\log(v_i) = const. + \sum_{1}^{K} \widetilde{\gamma}_k W_{ki} + \sum_{1}^{J} \widetilde{\beta}_j X_i + \varepsilon_i \qquad (3)$$

where the subscript i denotes a certain firm.

In order to test whether the training decision of a firm has any influence on its labour productivity, the model of Crépon et al. (2002) is extended by a variable of training intensity T_i. Our final model is

$$\log(v_i) = const. + \sum_{1}^{K} \widetilde{\gamma}_k W_{ki} + \sum_{1}^{J} \widetilde{\beta}_j X_i + \widetilde{\delta} T_i + \varepsilon_i \qquad (4)$$

In the empirical analysis we shall differentiate labour by age, gender, educational attainment, occupational classification and number of hours worked (see Table 1), which is included in the second term of equation (4). Unfortunately we can apply only a rough classification for hours worked into part-time versus full-time employment. Firm-specific characteristics X_i include the size as well as the age of the firm and the information whether it is a multi-plant firm or not. Since value added is available only at the firm level,[7] our analysis is restricted to the latter and not extended to the plant level.

4 For details regarding the 'simple model' as well as the 'extended model' see Crépon et al. (2002) and Prskawetz et al. (2007) respectively.

5 Ilmakunnas and Maliranta (2002) use a step-by-step procedure in which they start off by including a comprehensive set of independent variables in their productivity estimates and show that, by applying a more and more limited data set (which also excludes capital), they obtain fairly consistent results.

6 Note that such a form is motivated by an underlying Cobb Douglas production function.

7 We interchangeably use the term 'firm' or 'enterprise' to denote the unit of analysis.

3. Data

3.1. Merging Procedure

We use a cross-section of matched employer-employee data from Statistics Austria for the year 2001.[8] The data set emerged from matching firm level data of structural business statistics[9] (including economic indicators of 34,375 enterprises at the end of 2001) with the population census (including socio-demographic indicators of 1,563,873 employees on 15 May 2001) of Austria.

The matched employer-employee data set is somewhat noisy, since not every employee in the population census could be assigned to a firm nor could every enterprise be assigned to at least one employee. In our analysis we assume that the matching process did not cause any systematic bias and that the sample is representative for Austrian industries.

In the end, the matched employer-employee data allow us not only to control for possible firm-specific effects such as size and age of firm or type of organisation (e.g., multi-plant versus single-plant firms), but also to compare the productivity levels of enterprises with different age and educational structures of their employees.[10]

As a further step, we link the matched employer-employee data set with the data of the second Continuing Vocational Training Survey (CVTS2). This survey was conducted by Statistics Austria in 2001 and captures information about training decisions as well as training efforts in Austrian firms for the year 1999. Similar surveys were carried out by all members and candidate countries of the European Union. The data were collected by a questionnaire from a sample of firms randomly selected from the firm register of Statistics Austria during the first term of 2001. In contrast to the structural business survey (that is mandatory), the firms responded voluntarily.

The purpose of this survey was to obtain some key information about the training provided by firms for their employees. The focus here is on continuing vocational training. 'Continuing vocational training' is defined as training measures or activities, which are partly or completely financed by the enterprise in order to reward the employees having a working contract. Continuing vocational training measures and activities in turn include continuing vocational training courses (CVT

8 For a more detailed description of the data and variables see Prskawetz and Lindh (2006).

9 Our data are collected from the Structural Business Survey (in 2001) of Statistics Austria. The Structural Business Statistics are produced by extrapolating the results of the survey to the main part of the Austrian economy. For details of sample selection and the focus of the survey as well as the extrapolation mechanism see Statistics Austria (2003a).

10 For details regarding the merging procedure of these two data sets see Prskawetz et al. (2007).

courses) and other forms of continuing vocational training. Thereby, training courses are events designed solely for the purpose of providing training or vocational education taking place outside of the work place. This might be in a classroom or training centre, for instance, where a group of people receives instructions from teachers/tutors/lecturers for a period of time specified in advance by those organising the course. The survey did not cover initial vocational training provided to apprentices and others who have a training contract.

The CVTS2 covers NACE[11] sections C to K plus O[12] and contains selected information about training activities of 2,612 enterprises.[13] The indicators include structural data (e.g., total number of employees, total hours worked, total personnel cost, etc.), information on training policy (e.g., whether the enterprise assesses the skills and training needs), continuing vocational training courses (e.g., type and focus of trainings, number of employees participating in trainings, training expenditure, time spent in training courses, etc.), other forms of continuing vocational training and reasons not to provide continuing vocational training at all in 1999.[14]

Since only firms with at least ten employees are included in the CVTS2 we split our sample of 34,374 firms that emerged from the merging of the structural business statistics and the population census into one sub-sample of 'small firms' (at most nine employees) and one sub-sample of 'large firms' (at least ten employees). While the former sample contains 17,003 firms, the latter sample comprises 17,371 firms. The sub-sample of firms employing ten employees or more are further merged with the training information based on CTVS2. The resulting sample is called 'CVTS-firms' and contains 1,889 firms that have answered the CVTS2 survey. Since not all firms included in the CVTS-firm data set have provided training, we also have a control group of firms not providing training in this new reduced sample. Summing up, we have set up four different data sets: 1. the full sample that includes all the firms – independent of the size ('all firms'), 2. the sample that only includes firms with less than ten employees ('small firms'), 3. the sample that only includes firms with at least ten employees ('large firms') and 4. the sample that includes all firms with at least ten employees and information on firm specific training ('CVTS firms').[15]

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11 NACE = Nomenclature of economic activities; a code, that represents the classification of economic activities within the European Union, for further details see Table A.1 in the appendix.

12 Since the structural business survey does not cover the NACE section O, firms of this sector drop out once we link the CVTS2 data with the employer-employee data.

13 While the questionnaire has been sent to 6,908 firms, 2,612 of these responded, which corresponds to a rate of 37,8%.

14 For further details about CVTS2 in the European Union see EUROSTAT (2000). Findings from CVTS2 for Austria are published in Statistics Austria (2003b).

15 For an illustration regarding the merging procedure and sample size see Figure A.1 in the appendix.

The matching of the employer-employee data with the data of CVTS2 introduces two different biases. Firstly, firms are observed at two different points in time. The training activities are surveyed for 1999, whereas the economic data are collected for 2001. When firms disappear and henceforth drop out of the sample between 1999 and 2001 a so-called 'survival bias' may result. But, as only those firms can be interviewed about their past training activities, which also survived until 2001, this bias only rests upon the time difference between the two points in time of data collection and might therefore be neglected. Secondly, as firms replied voluntarily and were not obliged to answer by law, a 'selection bias' might play an important role. For instance, a certain firm might be more in favour to reply to the questionnaire if it offers training to its employees.

During the two years in-between 1999 and 2001 firms may undergo several additional changes that need not necessarily introduce a bias, but need to be controlled for. Firms may change size, because they grow or shrink, either due to changes in the market or because of mergers, acquisitions or takeovers, outsourcing of business activities (e.g., maintenance of computer equipment) or splitting into formally separate companies, etc. Such developments not only alter the size of the firm, but also the structure of the workforce in terms of age, education and other characteristics influencing productivity. However, these activities do not change the ID number of the firm. As no information about mergers, splittings etc. is included in the data set, only a change in the number of employees or value added can be observed, but the reason underlying these changes is unknown.

3.2. Descriptive Statistics

Compared to the sample of 'large firms' the characteristics of the CVTS-firms sample is rather different. Firstly, as a consequence that the intersection of both samples is low in addition to the two biases described above, many observations dropped out of the sample.[16] Secondly, due to several missing values in the data some further firms had to be dropped.[17] Hence, the number of firms used in the analyses was reduced to 1,788. Thirdly, the mixture of firms in terms of sectors changed remarkably. Compared to the sample of large firms the share of firms from mining and manufacturing industries is higher while the share of firms belonging to the service industries is lower.

16 723 firms from CVTS2 data dropped out, because they were not in the sample of structural business statistics. Vice versa, many observations from structural business statistics were lost, because they were not in the sample of CVTS2. Due to merging the number of firms has been reduced to 1,889.

17 634 firms dropped out, because of missing values.

Table 1: Descriptive statistics - determinants of productivity in 2001

variables	'All firms'		'Small' firms		'Large' firms		'CVTS' firms	
	Mean	Stand. dev.	Mean	Stand. dev.	Mean	Stand. dev.	Mean	Stand. dev.
Sample size (in no. of firms)	34,374		17,003		17,371		1,788	
Firm characteristics								
Value added per worker (in TEUR)	53.05	523.76	53.71	735.58	52.40	115.07	54.86	53.01
Size of firm (in persons employed)	46.65	393.27	3.75	2.46	88.63	549.98	209.81	1 270.97
Age of firm (in years)	15.83	15.77	12.97	12.45	18.57	17.98	23.78	22.35
Multiplant (0, 1)	0.20	0.40	0.08	0.27	0.32	0.47	0.46	0.50
Investment in fixed assets per worker (in TEUR)	17.26	478.64	22.47	659.04	12.20	172.34	9.52	32.59
Sector affiliation								
NACE C (mining and quarrying)	0.00	0.07	0.00	0.07	0.01	0.07	0.02	0.15
NACE D (manufacturing)	0.26	0.44	0.18	0.39	0.33	0.47	0.55	0.50
NACE E (electricity, gas and water supply)	0.01	0.08	0.01	0.08	0.01	0.08	0.02	0.15
NACE F (construction)	0.13	0.34	0.09	0.29	0.17	0.38	0.10	0.30
NACE G (wholesale and retail trade;…)	0.27	0.45	0.33	0.47	0.22	0.41	0.13	0.33
NACE H (hotels and restaurants)	0.09	0.29	0.13	0.37	0.05	0.22	0.04	0.19
NACE I (transport, storage and communication)	0.05	0.22	0.04	0.20	0.06	0.24	0.05	0.23
NACE J (financial intermediation)	0.02	0.15	0.02	0.17	0.02	0.13	0.05	0.21
NACE K (real estate, renting & business activities)	0.16	0.36	0.18	0.39	0.13	0.34	0.05	0.21
Region								
NUTS 11 (Burgenland)	0.03	0.17	0.03	0.18	0.03	0.16	0.03	0.17
NUTS 12 (Lower Austria)	0.16	0.37	0.16	0.36	0.17	0.37	0.17	0.38
NUTS 13 (Vienna)	0.21	0.41	0.20	0.40	0.22	0.41	0.19	0.40
NUTS 21 (Carinthia)	0.07	0.25	0.07	0.27	0.06	0.23	0.05	0.22
NUTS 22 (Styria)	0.14	0.34	0.14	0.35	0.13	0.33	0.13	0.34
NUTS 31 (Upper Austria)	0.16	0.37	0.14	0.34	0.18	0.39	0.20	0.40
NUTS 32 (Salzburg)	0.08	0.27	0.08	0.28	0.08	0.27	0.07	0.25
NUTS 33 (Tyrol)	0.10	0.30	0.11	0.31	0.09	0.28	0.10	0.30
NUTS 34 (Vorarlberg)	0.06	0.23	0.06	0.24	0.05	0.23	0.06	0.24

Variables	'All firms'		'Small' firms		'Large' firms		'CVTS' firms	
	Mean	Stand. dev.	Mean	Stand. dev.	Mean	Stand. dev.	Mean	Stand. dev.
Sample size (in no. of firms)	34,374		17,003		17,371		1,788	
Training intensity								
Share of trained employees in 1999	-	-	-	-	-	-	0.22	0.25
Share of time spent in trainings in 1999	-	-	-	-	-	-	0.003	0.006
Share of training expenditure in 1999	-	-	-	-	-	-	0.005	0.006
Employee-characteristics								
Proportion of employees								
Aged under 30 ('young')	0.26	0.22	0.21	0.25	0.32	0.16	0.28	0.13
Aged 30 to 49 ('prime-aged')	0.56	0.25	0.58	0.33	0.54	0.14	0.56	0.11
Aged over 49 ('old')	0.18	0.22	0.21	0.29	0.15	0.10	0.16	0.09
Herfindahl index (of age concentration)	0.57	0.22	0.68	0.25	0.47	0.09	0.45	0.07
Proportion of								
Basic education	0.23	0.22	0.22	0.27	0.25	0.16	0.27	0.15
Lower secondary education	0.58	0.28	0.58	0.35	0.57	0.19	0.59	0.16
Upper secondary education	0.13	0.20	0.14	0.25	0.13	0.13	0.11	0.11
Tertiary education	0.06	0.16	0.07	0.19	0.05	0.11	0.04	0.06
Proportion of								
Male employees	0.61	0.31	0.56	0.35	0.66	0.26	0.68	0.26
Female employees	0.39	0.31	0.43	0.35	0.34	0.26	0.33	0.26
Proportion in occupation								
Self-employed	0.21	0.32	0.39	0.36	0.03	0.05	0.01	0.02
White collar	0.38	0.34	0.34	0.36	0.42	0.32	0.37	0.28
Blue collar	0.37	0.33	0.24	0.30	0.49	0.31	0.56	0.28
Apprenticeship	0.05	0.10	0.03	0.09	0.06	0.10	0.05	0.08
Home worker	0.00	0.04	0.00	0.02	0.00	0.06	0.01	0.10
Proportion of								
Part-time	0.13	0.21	0.16	0.25	0.11	0.16	0.09	0.15
Full-time	0.87	0.21	0.84	0.25	0.89	0.16	0.91	0.15

Source: Matched employer-employee dataset, own calculations.

Descriptive statistics (mean values and standard deviations for selected characteristics) for all four samples are presented in Table 1.[18]

Firms included in the 'CVTS firm' sample are particularly characterised by a much larger workforce with 210 employees per enterprise on average. This size effect goes along with a higher average share of males of 68% (a decreasing share of females), a higher age of the firm (24 years on average), a larger share of multi-plant firms (46% on average) and a lower share of self-employed[19] of only 1%, as well as a poorer average share of investments into fixed assets per worker. Moreover, the small firms can predominantly be found within sectors of wholesale and retail trade (NACE G), whereby the CVTS firms are relatively strongly represented within the manufacturing sector (NACE D).

Also the age composition of the workforce differs across the four samples. Among small firms, the youngest (below age 30) and the oldest (above age 49) age groups are of the same size on average with 21% each. Overall, the share of the oldest age group in small firms is highest among our samples. The share of prime-age workers (30 to 49 years) dominates for each sample, accounting for more than 50% of all employees on average. We introduce a further indicator regarding the distribution of the age groups within a firm by making use of the 'Herfindahl index', which shows, that the degree of age concentration is much higher for small firms than for large ones. In other words, there are a lot of firms among those with less than ten employees, whose age structure is nearly completely concentrated. On the contrary, enterprises with at least ten employees have a rather balanced age structure.

Educational levels are grouped by attainment into (a) basic education (up to nine years), (b) upper secondary education with medium skill attainment, which includes apprenticeships and short cycle vocational education (ten to twelve years of schooling), (c) upper secondary education with higher skill attainment, which encompasses the Austrian gymnasium and its equivalents, such as vocational colleges (twelve to thirteen years of schooling) and (d) tertiary education including post-graduate studies, teacher training colleges, etc. The medium skill upper secondary education (referred to as 'lower secondary education' in the tables) is the most prevalent category with nearly 60%.

Obviously, the selection bias (caused by the fact that firms replied voluntarily in the CVTS) introduces a rather different structure of enterprises for the 'CVTS firms' sample.

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18 For the sake of completeness we also show descriptive statistics as well as analytical results for the full sample.

19 We group occupational affiliations into five categories: selfemployed, white-collar workers, blue-collar workers, apprenticeships and home workers.

In the 'CVTS firms' sample we can measure training intensity by three different indicators. The first one is the number of employees trained divided by the average number of employees in a firm in 1999. A drawback of this measure is that it does not take into account the length of the training course employees participated in (Zwick 2006: 35). This is why we defined two further measures of training intensity. The second indicator is the number of hours spent in training courses divided by the total number of hours worked in 1999. Our third training measure is the money devoted for training courses by a firm relative to total personnel costs. In the average firm, of those who indeed provide training to their employees (1,239 out of 1,788 firms), we can observe that nearly one third of all employees have been trained. By contrast, the relative time spent in training, as well as the share of training expenditures are rather negligible. Thus, within the 'CVTS sample' we can distinguish between firms which do and firms which do not provide any training at all (549 out of 1,788 firms).

In order to check, whether there might be a certain pattern observed, by which the training firms can be systematically distinguished from the non-training firms, we take a closer look at some characteristics which might drive potential endogeneity of training and productivity. Besides the variations we find, when breaking down the data over sectors, the following facts for the 'CVTS firms' sample emerge[20]:

Enterprises that do not provide any training are younger (i.e., they have been on the market for a shorter time) as compared to training firms and they are characterised by a slightly older age structure of their employees. With only 53 employees, as compared to 279 employees within training firms, non-training firms are marked by a smaller firm size and are only in 39% (as compared to 49%) of the cases designed as multi-plant enterprises. Non-training firms employ a higher share of women and are characterised by a higher share of basically educated employees compared to training firms. The latter fact may hint towards a positive correlation between education and training. The gap between fewer white-collar workers in relation to more blue-collar workers is even wider for non-training than for training firms. Moreover, investments into fixed assets are on a smaller scale for firms that do not provide any training to their employees.

Non-training firms can be found more often in NACE F (construction) and H (hotels and restaurants), whereas seldom in NACE E (electricity, gas and water supply), G (wholesale and retail trade) and J (financial intermediation). This irregular distribution across sectors might also be a reason for the varying results when breaking down the samples.

Additionally, in order to indicate firms according to their technology intensity, we classify firms regarding the taxonomy of O'Mahony and van Ark (2003) into

20 For details see Table A.2 in the appendix.

ICT-categories.[21] Non-training firms are more often of NICTM-type (Non-ICT-Manufacturing), rather seldom of ICTPM (ICT-Producing Manufacturing) or ICTUS (ICT-Using Services) type and they are more often located in Lower Austria (NUTS 12) whereas less often located in Upper Austria (NUTS 31)[22] than training ones. Overall, based on the descriptive statistics, one can discover that non-training firms are less productive on average than firms providing training.

These descriptive results are confirmed by conducting a Tobit regression[23] in which we model the relationship between the censored[24] dependent variable 'share of trained employees within a firm', and a vector of independent variables. We apply this regression to the sample of 'CVTS firms'. Our results indicate that firms with a higher share of elderly, belonging to the NACE categories E (electricity, gas and water supply), G (wholesale and retail trade), I (transport storage and communication), J (financial intermediation) and K (real estate, renting and business activities) and located in Carinthia (NUTS 21) provide systematically more training.

With regard to the sector distribution across samples and (NUTS-) regions we can generally say that the sectors G (whole sale and retail trade) and D (manufacturing) are the most predominant ones with a total of 8,908 and 9,439 firms respectively, while the larger the firms the more predominant is sector D and the other way around. Admittedly, sector K (real estate, renting and business activities) is relatively strong represented in Vienna (NUTS 13) which is the same for sector H (hotels and restaurants) in Tyrol (NUTS 33). In contrast to this the sectors C (mining and quarrying) and J (financial intermediation) are underrepresented. Overall, only 168 firms are carrying out their business in mining and quarrying (NACE C).

4. Regression Analysis

4.1. Constructing the Regression Equation

In Prskawetz et al. (2007) our analysis is based on the full matched employer-employee sample and the influence of vocational training is not considered. In this study we extend our previous work by incorporating indicators of training intensity into our model in order to control for training activities. We thereby test whether

21 ICT = Information and Communication Technology; for further details see appendix, Table A.4.

22 For details regarding the NUTS (= Nomenclature of Territorial Units for Statistics) classification see appendix, Table A.3.

23 Results are not shown here.

24 The 'share of trained employees' lies in-between the lower bound zero (for non-training firms) and the upper bound one.

the hump-shaped age structure's effect is based on omitted variable bias and whether it can be filtered out by incorporating age and training separately. As data of vocational training is available only for a small proportion of firms a part of the analysis is based on a reduced sample, as described in the previous sections.
In this section we first of all present our results that refer to the full matched employer-employee sample. Afterwards we show outcomes for our three sub-samples. These encompass small firms, large enterprises (which were supposed to answer questions on their training behaviour) and the 'CVTS firm' sample. Analyses based on the reduced 'CVTS firm' sample are conducted firstly without controlling for training activities and secondly in consideration of training.

The following OLS (= ordinary least squares)-regressions are performed at the enterprise level. We report outcomes of all estimates and discuss results taking into consideration the consequences of selection biases.

The dependent variable in all regressions is the natural logarithm of value added per worker, whereas the denominator is the average number of workers in 2001 as given in the structural business statistics. Whenever possible, the independent variables are taken from the structural business statistics as well. While several socio-demographic variables such as age and educational level (both measured as shares) have to be taken from 2001 census, we took our indicators of training activities from CVTS2. The fact that we could not match all of the workers implies that some of the independent variables are based on a sample that is smaller than the number of workers in the structural business statistics. The results of the estimates are presented in Tables 2a and 2b. It includes regression results for the full matched employer-employee sample (Table 2a column 2), as well as for the two samples subdivided into small (Table 2a column 3) and large (Table 2a column 4) firms and the further reduced sub-sample of CVTS firms that provided an answer on the CVTS2 (Table 2b). Within the latter sub-sample we present two models, one where we exclude training variables (Table 2b column 2) and one where we control for training variables (Table 2b columns 3 and 4). The regression coefficients on the age categories presented in the subsequent tables indicate the marginal effect of an increase in the respective share, assuming that the omitted share adjusts.

For every sample value added per worker is regressed on three age-share variables, the Herfindahl index, four educational-share variables, the share of gender, firm-specific variables such as the logarithm of the size of the firm (in terms of the number of employees and measured by a continuous variable), the logarithm of the firm's age (measured by a continuous variable), whether or not it is a multi-plant firm (coded as a dummy variable) and the logarithm of the level of investment (in tangible assets). A further set of variables contains the share of workers in various occupations as well as the share of part-time workers, nine NACE-categories as well as nine regional dummies (NUTS-categories) for Austria. As reference categories we choose the share of prime-aged workers, the share of basic educated workers, the

share of male employees as well as the shares of blue-collar workers, full-time workers, NACE D (manufacturing) and NUTS 34 (Vorarlberg). The training variable is added for the CVTS firms only.[25]

Table 2a: Explaining labour productivity (= ln (value added per worker)) in 2001

Variables	'All firms'		'Small firms'		'Large firms'	
	Coeff.	S.e.	Coeff.	S.e.	Coeff.	S.e.
Share of trained employees	-	-	-	-	-	-
Proportion of employees						
Aged under 30	-0.22***	0.025	-0.14***	0.034	-0.42***	0.044
Aged 30 to 49 (r.c.)	-	-	-	-	-	-
Aged over 49	-0.16***	0.021	-0.19***	0.027	-0.11*	0.066
Herfindahl index	-0.40***	0.028	-0.54***	0.038	-0.19***	0.065
Proportion of						
Basic education (r.c.)	-	-	-	-	-	-
Lower secondary edu.	0.10***	0.021	0.07**	0.028	0.25***	0.037
Upper secondary edu.	0.28***	0.029	0.21***	0.038	0.63***	0.055
Tertiary education	0.35***	0.036	0.26***	0.047	0.79***	0.063
Proportion of						
Male employees (r.c.)	-	-	-	-	-	-
Female employees	-0.35***	0.017	-0.35***	0.024	-0.26***	0.024
Ln (size of firm)	-0.03***	0.004	-0.23***	0.015	-0.01	0.005
Ln (age of firm)	0.05***	0.004	0.07***	0.008	0.04***	0.005
Multiplant	-0.05***	0.012	-0.03	0.026	-0.06***	0.011
Ln (investment)	0.03***	0.001	0.04***	0.001	0.03***	0.001
Proportion in occupation						
Self-employed	-0.65***	0.024	-0.82***	0.037	-1.47***	0.106
White collar	0.54***	0.019	0.49***	0.310	0.38***	0.025
Blue collar (r.c.)	-	-	-	-	-	-
Apprenticeship	-0.72***	0.052	-0.45***	0.086	-0.56***	0.062
Home worker	0.71***	0.102	0.24	0.384	0.31***	0.089
Proportion of						
Part-time	-0.71***	0.022	-0.67***	0.031	-0.76***	0.033
Full-time (r.c.)	-	-	-	-	-	-

25 We only show the result emanating from a regression on 'the share of employees taking part in CVT activities', as making use of the other two training measures instead does not alter our conclusions.

Variables	'All firms'		'Small firms'		'Large firms'	
	Coeff.	S.e.	Coeff.	S.e.	Coeff.	S.e.
Sector affiliation						
NACE C	0.45***	0.061	0.57***	0.106	0.37***	0.064
NACE D (r.c.)	-	-	-	-	-	-
NACE E	0.60***	0.063	0.53***	0.119	0.55***	0.063
NACE F	0.12***	0.015	0.25***	0.029	0.06***	0.015
NACE G	-0.14**	0.013	-0.10***	0.022	-0.15***	0.015
NACE H	-0.15***	0.018	-0.11***	0.028	-0.17***	0.024
NACE I	-0.19***	0.021	-0.25**	0.039	-0.14***	0.021
NACE J	0.03	0.032	-0.14***	0.049	0.34***	0.040
NACE K	-0.09***	0.016	-0.07**	0.027	-0.08***	0.019
Region						
NUTS 11	-0.16***	0.030	-0.16***	0.049	-0.18***	0.035
NUTS 12	-0.12***	0.021	-0.13***	0.035	-0.13***	0.023
NUTS 13	-0.07***	0.021	-0.05	0.035	-0.15***	0.023
NUTS 21	-0.10***	0.025	-0.10**	0.040	-0.14***	0.028
NUTS 22	-0.13***	0.021	-0.12***	0.035	-0.17***	0.024
NUTS 31	-0.06***	0.021	-0.06	0.036	-0.09***	0.023
NUTS 32	-0.03	0.023	-0.03	0.039	-0.06**	0.026
NUTS 33	-0.06***	0.023	-0.08**	0.037	-0.05*	0.025
NUTS 34 (r.c.)	-	-	-	-	-	-
Constant	4.02***	0.038	4.36***	0.064	3.85***	0.063
Adjusted R^2	0.29		0.25		0.26	
F-test	426.31***		167.60***		182.26***	
No. of observations	32 846		15 991		16 855	

Table 2b: Explaining labour productivity (= ln (value added per worker)) in 2001

Variables	'CVTS firms' Excl. training		'CVTS firms' Incl. training		'CVTS firms' Excl. NACE	
	Coeff.	S.e.	Coeff.	S.e.	Coeff.	S.e.
Share of trained employees	-	-	0.08	0.058	0,16***	0,059
Proportion of employees						
Aged under 30	-0.23	0.185	-0.23	0.185	-0,42**	0,188
Aged 30 to 49 (r.c.)	-	-	-	-	-	-
Aged over 49	-0.04	0.251	-0.02	0.251	-0,00	0,258
Herfindahl index	0.06	0.288	0.07	0.288	-0,05	0,296

Variables	'CVTS firms' Excl. training		'CVTS firms' Incl. training		'CVTS firms' Excl. NACE	
	Coeff.	S.e.	Coeff.	S.e.	Coeff.	S.e.
Proportion of						
Basic education (r.c.)	-	-	-	-	-	-
Lower secondary edu.	0.46***	0.116	0.45***	0.117	0,47***	0,120
Upper secondary edu.	0.92***	0.198	0.90***	0.200	1,39***	0,191
Tertiary education	1.00***	0.268	0.96***	0.270	1,03***	0,271
Proportion of						
Male employees (r.c.)	-	-	-	-	-	-
Female employees	-0.33***	0.071	-0.32***	0.071	-0,25***	0,068
Ln (size of firm)	0.02	0.013	0.01	0.013	-0,00	0,013
Ln (age of firm)	-0.01	0.013	-0.01	0.013	-0,00	0,013
Multiplant	-0.05*	0.029	-0.05*	0.029	-0,04	0,029
Ln (investment)	0.04***	0.004	0.04***	0.004	0,05***	0,004
Proportion in occupation						
Self-employed	-1.15**	0.567	-1.18**	0.567	-1,54***	0,583
White collar	0.22***	0.078	0.21***	0.078	0,16**	0,071
Blue collar (r.c.)	-	-	-	-	-	-
Apprenticeship	-0.92***	0.214	-0.93***	0.214	-0,95***	0,217
Home worker	0.23	0.157	0.24	0.157	0,57***	0,149
Proportion of						
Part-time	-0.72***	0.104	-0.72***	0.104	-0,76***	0,10
Full-time (r.c.)	-	-	-	-	-	-
Sector affiliation						
NACE C	0.30***	0.087	0.30***	0.087	-	-
NACE D (r.c.)	-	-	-	-	-	-
NACE E	0.54***	0.091	0.53***	0.092	-	-
NACE F	-0.04	0.047	-0.03	0.047	-	-
NACE G	-0.23***	0.047	-0.23***	0.047	-	-
NACE H	-0.16**	0.075	-0.15**	0.075	-	-
NACE I	-0.08	0.058	-0.08	0.058	-	-
NACE J	0.48***	0.082	0.47***	0.083	-	-
NACE K	0.04	0.069	0.04	0.069	-	-
Region						
NUTS 11	-0.08	0.092	-0.08	0.092	-0,15	0,095
NUTS 12	-0.167***	0.062	-0.16***	0.062	-0,19***	0,064
NUTS 13	-0.13**	0.063	-0.13**	0.063	-0,21***	0,064
NUTS 21	-0.21***	0.081	-0.21***	0.081	-0,23***	0,083
NUTS 22	-0.16**	0.066	-0.16**	0.066	-0,17**	0,068
NUTS 31	-0.15**	0.060	-0.15**	0.060	-0,18***	0,062
NUTS 32	-0.04	0.072	-0.04	0.072	-0,08	0,074
NUTS 33	-0.06	0.066	-0.06	0.066	-0,08	0,068

NUTS 34 (r.c.)	-	-	-	-	-	-
Constant	3.67***	0.234	3.68***	0.234		
Adjusted R^2	0.35		0.35		0,30	
F-test	30.78***		29.92***		32,04**	
No. of observations	1 788		1 788		1 788	

Source: matched employer-employee data set, own calculations.
Note1: s.e. = standard error.
Note2: r.c. = reference category.
Note3: *** significant at 1%-level. ** significant at 5%-level. * significant at 10%-level.

4.2. Estimating Productivity Effects of the Employees' Age Structure - Controlling for Training at the Firm Level

We find a hump-shaped pattern of the age structure's impact on a firm's value added that seems to weaken for larger sized firms. The hump-shaped pattern is significant on the 1%-level for the smaller firms. That is, firms where the share of young (or old) workers increases (and the share of prime-age workers adjusts) by 1 percentage point, exhibit on average 0.14% (0.19%) less productivity. To calculate the effect of an increase in the share of old workers, assuming that the share of young workers adjusts, one can take the difference between the two coefficients. Moreover, the Herfindahl index is negatively significant, which means that firms with a higher degree of concentration regarding its workforce's age composition suffer from significantly lower labour productivity (-0.54). This corresponds to the idea of complementarity between workers of different age groups, e.g., senior workers instructing beginners. For the 'CVTS sample' the results are different. The hump-shaped pattern of the age variables completely disappears and the age concentration within a firm does not matter anymore. This finding is irregardless of whether we control for training or not (Table 2b columns 3 and 4). Thus, the differences in the results could partly reflect the influence of the selection bias. In the 'CVTS sample' firms are older and especially larger on average than in the sample of large firms and the structure of economic sectors is different as well. These three factors seem to be the driving forces that underlie the changing results with respect to the age composition of the workforce. The diminishing impact of the hump-shaped age structure already becomes apparent in Table 2a column 4 (the sample of large firms) where – although the coefficient for the youngest age group even grows (-0.42) and is still significant on 1%-level – the coefficient for the oldest age group becomes rather small (-0.11) and is only significant at 10%-level. Moreover, the Herfindahl index is much lower (-0.19) for this sample compared to the small firms.

With regard to education we find that – relative to basic education – an increase in the share of tertiary, upper secondary education with higher skill attainment and upper secondary education with medium skill attainment positively affects

productivity in all samples. The positive effects of all three categories of education are highly significant.

Compared to the share of males, an increasing share of women is associated with decreasing labour productivity throughout, which might be due to the fact that females often tend to work part-time. Unfortunately, we are not able to control for hours worked, but included the shares of part-time workers which are significantly negative for all samples as well.

Regarding firm-specific characteristics we can observe that – besides the size – the age of the firm plays a more important role for small firms whereas being a multi-plant firm has a negative coefficient and is more important for larger firms. Apparently, much more multi-plant firms can be found within the 'large firms'. Investments matter positively and to the same extent for all firms.

While a rising share of self-employed persons and apprentices lead to decreasing productivity, an increase in white-collar workers compared to blue-collar workers is positively associated with productivity at the firm level.

As already mentioned, the share of part-time employees has a significantly negative impact on productivity for firms of any size as compared to full-time employees. Due to individual fixed costs part-time workers are relatively more expensive for firms than full-time workers. Moreover, a higher number of part-time employees by definition reduces output per worker as compared to a smaller number of full-time employees producing a value added of identical size.

The sector affiliation of a firm as well as its location within Austria should obviously be considered, as we nearly exclusively find significant coefficients for the respective dummy variables. While the pattern within the sectors is rather mixed, all regional dummies show up a negative coefficient in reference to the most western Austrian state Vorarlberg (NUTS 34).

For the last sample we extend the econometric setup by adding an indicator for training intensity in 1999, namely the share of workers trained in relation to the total number of employees. The influence of vocational training turns out to be positive and clearly significant as long as we do not control for the sector affiliation of the firm, i.e., as long as we do not include the sector dummies (see Table 2b column 4). Firstly, this means that the higher the training intensity in 1999, the higher the labour productivity in 2001.[26] But, secondly, the training intensity clearly depends on the NACE category to which the respective enterprise belongs.

Overall, the educational level and the sector affiliation provide the largest contribution in explaining productivity at the firm level in terms of (adjusted) R^2. The strong impact emanating from sector dummies can usually be traced back to sys-

26 The time difference between occurrence of training and observation of productivity is two years and fixed by the survey dates. However, two years might be a plausible time interval for training efforts to become effective in terms of productivity progression.

tematic and technologically determined differences of labour intensity and labour productivity regarding production processes between the sectors.

Additionally, we tried to control for potential endogeneity of the age structure within an enterprise by using an instrumental variable approach, which has not led to the desired effect as we were lacking an appropriate instrument. The regressions regarding 'CVTS firms' (Table 2b columns 2 and 3) have also been analysed making additional use of the two-step 'Heckman' procedure to correct for the selection bias, which also did not alter our results decisively. Moreover, implementing an interaction coefficient of age and training, i.e., including 'age*training' as an additional independent variable, does not lead to any significant result. Hence, we feel impelled to exclude the possibility of any combined effect.

5. Robustness Checks

In order to verify the robustness of our results from the regression analysis, we perform several checks. Firstly, we choose a different firm size (in terms of the number of employees) to distinguish between 'small' and 'large' firms, secondly we use another index to control for the age concentration within a firm, thirdly we perform the regression analysis for each sector separately and fourthly, we raise the number of age groups by choosing smaller age intervals.

5.1. 'Small' versus 'Large' Firms

As compared to our threshold level of ten employees to distinguish between small and large firms, we choose 50 employees as the alternative threshold. The aim is to check whether our results are firstly, robust with regard to choosing this borderline between small and large firms and secondly, whether our current results are in line with our former study where we also applied a threshold level of 50 employees to distinguish between small and large firms (see Prskawetz et al. 2007).

It turns out that the hump-shaped influence of a firm's age structure on its productivity as well as the Herfindahl index are still strongly significant (on 1%-level) for 'small' firms, while this pattern disappears for 'large' firms. Solely the youngest age group still has a significantly negative coefficient. Thus, the results from our robustness check regarding the 'small' firms is consistent with the results from Prskawetz et al. (2007). In contrast to that, the significance for our 'large' firm sample depends on the threshold (i.e., the number of employees) chosen that distinguishes between small and large firms. Since the sample size of large firms shrinks the higher we set this threshold, statistical significance is getting less likely for those firms.

5.2. Index of Age Concentration

Analogously to Prskawetz and Fent (2007) we make use of an alternative index to measure the age concentration within a single firm, i.e., we switch from the Herfindahl index (where i denotes a certain age group, N its overall number of age groups and a_i the share of age group i):

$$\frac{1}{3} \leq \frac{\sum_{i=1}^{N} a_i^2}{(\sum_{i=1}^{N} a_i)^2} \leq 1$$

to the so-called 'dissimilarity index' (where $\tilde{x}_i$ identifies the actual share of age group i and x denotes the share in case of a uniform age distribution):

$$0 \leq \frac{1}{2} \sum_i (|\tilde{x}_i - x_i|) \leq \frac{2}{3}.$$

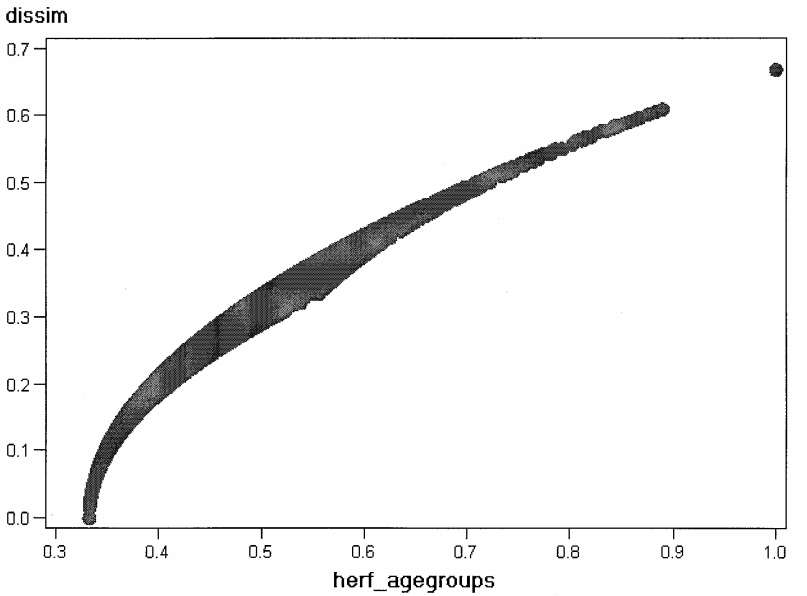
While the hump-shaped age pattern and the index of concentration - using the Herfindahl index - are slightly significant (on 10%-level) for 'large' firms this is not the case anymore using the dissimilarity index. As indicated in Figure 1 for higher orders of concentration – as typically characteristic for 'small' firms - both indices cover the same range (corresponding to an interval of 2/3) though the absolute scale differs. In the area of lower age concentration the curve is not linear, i.e., the dissimilarity index is more sensitive for low concentration – as typically characteristic for 'large' firms. However, significance for the oldest age group as well as the index itself disappears.

5.3. Firms Separated per Sector

Against the background of a varying distribution of the concentration index across sectors, systematic differences of technology and the awareness that the impact of training on productivity is sector-dependent, we applied our analysis to each sector for every sample, which yields 9 sectors * 5 samples = 45 regressions. Of course, we now run into trouble due to sample size problems for some sectors as well as multicollinearity, which especially holds for NACE J (financial intermediation). Moreover, the smaller the 'overall' sample the weaker the statistical significance (of the hump shape and age concentration) over sectors. While the hump shape as well as

the age concentration are still significant for sectors D (manufacturing), F (construction), H (hotels and restaurants) and K (real estate, renting and business activities) for 'all' firms, the age variables in sector F get insignificant for 'small' firms, while only in sector F the age variables are significant for 'large' firms. For the 'CVTS firms' sample troubles regarding multi-collinearity are severe and for our 'training' sample even the F-test becomes insignificant for some sectors. Overall, we can state that the outcome regarding age structure effects is very heterogeneous across sectors so that any potential effect on the macroeconomic aggregate should depend on the sector structure as a whole. ,

Figure 1: Indices of age concentration across 'all firms'



Note: dissim = dissimilarity index, herf_agegroups = Herfindahl index.
Source: matched employer-employee dataset, 'all firms'.

5.4. Age Groups

Finally, in order to check whether the hump-shaped age pattern can be confirmed for those samples where it already turned out to be significant when we even refine the age structure's classification, we switch from three (15 to 29 years, 30 to 49

years and 50+ years) to the following five age groups: 15 to 29 years, 30 to 39 years, 40 to 49 years, 50 to 59 years and 60+ years.

For 'all firms' the hump shape is conserved, while it peaks in the age group of the 30 to 39 year old employees. Thereby, the significance of the coefficient varies between 1%- and 5%-level, while it is even insignificant for one age group (50 to 59 years). Also the Herfindahl index is negative and strongly significant. The same applies to 'small firms'. Even for 'large' firms we can observe a significant and negative coefficient for the youngest (1%-level) as well as for the oldest (10%-level) age group which constitute the hump shape, while the two other age groups loose their impact. This is consistent with our former results as significance for the 'large' firm sample has always been the weakest one. The age concentration is still a significantly negative factor of determining a firm's labour productivity. No significance of any age coefficient – except for the youngest age group - can be found for 'CVTS firms'.

6. Conclusions

Summing up the results of our analysis, we find a simultaneous, negative productivity effect of the share of young workers (29 years and younger) and old workers (50 years and older) on labour productivity, which is consistent with our previous studies in samples of small as well as in samples of large firms. Only in a sub-sample of CVTS firms, which consists of enterprises that participated in the Continuous Vocational Training Survey, we are not able to find any significant effects of the workforce's age on productivity. The latter result is independent whether we control or do not control for training variables. Obviously this outcome is due to a 'selection effect'. Already within the sample of large firms the oldest age group looses significance. Since the CVTS firm sample is only a sub-sample of the sample of large firms (with the average firm being even larger) the fact that age variables loose their significance in the CVTS sample is not surprising.

We use three different indicators for training intensity, namely the share of employees trained in relation to the total number of employees, the share of time spent in trainings in relation to the total working time and the share of expenditure for trainings in relation to personnel costs. Independently of the specific indicator we used, the influence of vocational training turns out to be significantly positive as long as we do not include the sector dummies. Put differently, the higher the training intensity in 1999, the higher the labour productivity of a firm in 2001. This effect is invalidated as soon as we control for a firm's sector affiliation, which indicates that the positive effect emanating from training is different from sector to sector.

For educational shares we found that the share of upper secondary education with medium skill attainment, upper secondary education with higher skill attainment and tertiary education increase productivity.

As we have indicated throughout the text, our results need to be interpreted with caution because of several reasons. Firstly, we cannot control for endogeneity of the regressors within our cross-sectional data set. Moreover, the time gap of our training data (1999) and the matched employer-employee data (2001) is noteworthy. Recent literature shows that there is a time gap between the implementation of training activities and its positive impact on value added. (Moreover, there might even be a negative impact within the year when training takes place.) In order to account for potential endogeneity of training we would need data of the same year (1999) or even earlier. Since appropriate data are not available, it is not possible to implement an instrumental variable approach in this regard.

Secondly, our sample suffers from the fact that the number of firms it contains is rather small (compared to the full sample of the structural business statistics). This can be explained by the small intersection of the underlying structural business survey and CVTS data as well as the presence of a selection bias caused by the fact that firms reply in the CVTS was voluntarily. These restrictions introduce a rather different 'reduced sub-sample' ('CVTS firms') as compared to the complete sample of our previous studies and may distort our results.

Further research might address the identification of determinants influencing the employment of older workers in Austria, since also a firm's workforce is not exogenously given, but determined endogenously by the firm itself – or its management respectively.

Currently the construction of a panel is not possible, because the population census is conducted by Statistics Austria only every ten years and information on the plant-level identifier number for each person interviewed in the census is exclusively available in the 2001 version. (Structural business statistics and census data can be merged only by using this indicator.) Thus, we aim at going one step further into detail with our analysis by hopefully being able to use panel data in the future.

In conclusion, our question raised at the beginning – whether the hump-shaped age profile on firm productivity is robust once we control for training variables - cannot be answered with the data set, which is currently available. The hump-shaped age profile already looses significance once we restrict our regressions to the CVTS firms sample only – independent on whether we control for training or not. However, our results indicate that training is positively related to firm level productivity. Training may therefore be a valid tool to hold up or even increase firm level productivity when the workforce ages.

Appendix

Figure A.1: Merging procedure

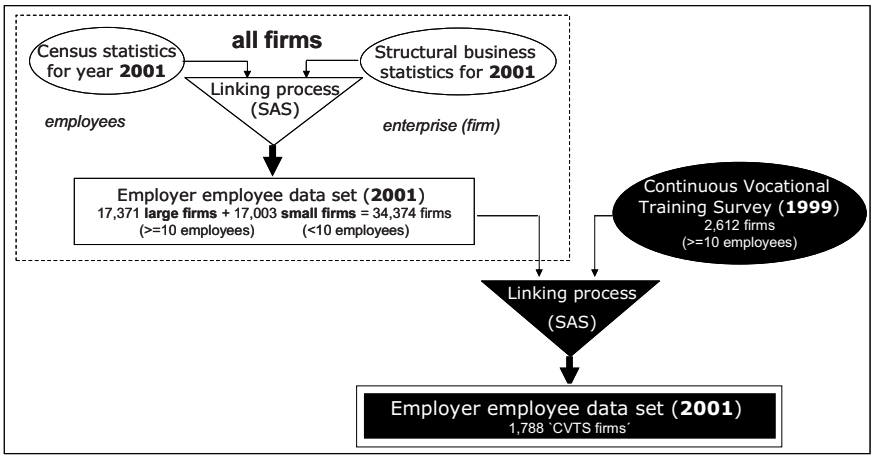


Table A.1: NACE categories

Code	Elements
A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
H	Hotels and restaurants
I	Transport, storage and communication
J	Financial intermediation
K	Real estate, renting and business activities
L	Public administration and defence; compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal service activities
P	Activities of households
Q	Extra-territorial organizations and bodies

Source: Statistics Austria (2007a).

Table A.2: Descriptive statistics – training firms vs. non-training firms

Variables	Training firms		Non-training firms	
	Mean	Standard dev.	Mean	Standard dev.
Sample size (in no. of firms)	1 239		549	
Firm characteristics				
Value added per worker (in TEUR)	59.55	58.46	44.29	35.79
Size of firm (in persons employed)	279.14	1 521.12	53.35	71.10
age of firm (in years)	25.10	23.84	20.81	18.21
Multiplant (0. 1)	0.49	0.50	0.39	0.49
Investment in fixed assets per worker (in TEUR)	10.76	35.43	6.70	24.81
Sector affiliation				
NACE C (mining and quarrying)	0.02	0.14	0.03	0.18
NACE D (manufacturing)	0.53	0.50	0.59	0.49
NACE E (electricity, gas and water supply)	0.03	0.17	0.01	0.07
NACE F (construction)	0.09	0.28	0.13	0.34
NACE G (wholesale and retail trade;…)	0.14	0.35	0.10	0.30
NACE H (hotels and restaurants)	0.03	0.16	0.06	0.24
NACE I (transport, storage and communication)	0.06	0.24	0.04	0.20
NACE J (financial intermediation)	0.06	0.24	0.01	0.09
NACE K (real estate, renting and business activities)	0.05	0.22	0.03	0.17
Region				
Nuts 11 (Burgenland)	0.03	0.17	0.03	0.17
Nuts 12 (Lower Austria)	0.16	0.37	0.20	0.40
Nuts 13 (Vienna)	0.19	0.39	0.21	0.40
Nuts 21 (Carinthia)	0.05	0.22	0.04	0.20
Nuts 22 (Styria)	0.13	0.34	0.13	0.34
Nuts 31 (Upper Austria)	0.21	0.41	0.17	0.38
Nuts 32 (Salzburg)	0.07	0.25	0.07	0.26
Nuts 33 (Tyrol)	0.09	0.29	0.11	0.31
Nuts 34 (Vorarlberg)	0.07	0.26	0.04	0.20
Training intensity				
Share of trained employees in 1999	0.31	0.25	-	-
Share of time spent in trainings in 1999	0.005	0.007	-	-
Share of training expenditure in 1999	0.008	0.012	-	-
Employee-characteristics				
Proportion of employees				
Aged under 30 ('young')	0.28	0.13	0.28	0.15
Aged 30 to 49 ('prime-aged')	0.56	0.10	0.55	0.13
Aged over 49 ('old')	0.16	0.08	0.17	0.11

Variables	Training firms		Non-training firms	
	Mean	Standard dev.	Mean	Standard dev.
Herfindahl index (of age concentration)	0.45	0.06	0.46	0.08
Proportion of				
Basic education	0.25	0.14	0.31	0.15
Lower secondary education	0.59	0.16	0.59	0.17
Upper secondary education	0.12	0.12	0.08	0.08
Tertiary education	0.04	0.07	0.02	0.04
Proportion of				
Male employees	0.69	0.25	0.64	0.28
Female employees	0.32	0.25	0.36	0.28
Proportion in occupation				
Self-employed	0.01	0.02	0.02	0.03
White collar	0.41	0.29	0.27	0.23
Blue collar	0.52	0.28	0.65	0.24
Apprenticeship	0.05	0.07	0.06	0.09
Home worker	0.02	0.12	0.01	0.07
Proportion of				
Part-time	0.09	0.14	0.10	0.16
Full-time	0.91	0.14	0.90	0.16

Source: matched employer-employee dataset own calculations.

Table A.3: NUTS categories

Code	**Area**
AT11	Burgenland
AT12	Lower Austria
AT13	Vienna
AT21	Carinthia
AT22	Styria
AT31	Upper Austria
AT32	Salzburg
AT33	Tyrol
AT34	Vorarlberg

Table A.4: ICT Taxonomy

ICT-Producing – Manufacturing: Office machinery (30); Insulated Wire (313); Electronic valves and tubes (321); Telecommunication equipment (322); Radio and television receivers (323); Scientific instruments (331).

ICT-Producing – Services: Communications (64); Computer & related activities (72).

ICT-Using – Manufacturing: Clothing (18); Printing & publishing (22); Mechanical engineering (29); Other electrical machinery & apparatus (31 without 313); Other instruments (33 without 331); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment nec (352 and 359); Furniture, miscellaneous manufacturing; recycling (36 and 37).

ICT-Using – Services: Wholesale trade and commission trade, except of motor vehicles and motorcycles (51), Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Financial intermediation, except insurance and pension (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67); Renting of machinery & equipment (71); Research & development (73); Legal, technical & advertising (741 to 743).

Non-ICT Manufacturing: Food, rink & tobacco (15 and 16); Textiles (17); Leather and footwear (19); Wood & products of wood and cork (20); Pulp, paper & paper products (2); Mineral oil refining, coke & nuclear fuel (23); Chemicals (24); Rubber & plastics (25); Non-metallic mineral products (28); Motor vehicles (34).

Non-ICT Services: Sale, maintenance and repair of motor vehicle and motorcycles; retail sale of automotive fuel (50); Hotels & catering (55); Inland transport (60); Water transport (61); Air transport (62); Supporting and auxiliary transport activities; activities of travel agencies (63); Real estate activities (70); Other business activities (749); Public administration and defence; compulsory social security (75); Education (80); Health and social work (85); Other community, social and personal services (90 to 93); Private households with employed persons (95); Extra-territorial organizations and bodies (99).

Non-ICT Others: Agriculture (01); Forestry (02); Fishing (05); Mining and quarrying (10 to 14); Electricity, gas and water supply (40 and 41); Construction (45).

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Older Workers and the Adoption of New Technologies in ICT-Intensive Services

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1 Introduction

In the face of the demographic development characterised by an increasing life expectancy and a simultaneous decrease in birth rates, the age structure of the working population changes. The employment rate of workers between 55 and 64 years has increased particularly in the last five years. In the EU-25 the employment rate of this age group has increased by 5.9% from 2000 to 2005 and amounts to about 42% (Aliaga et al. 2006). In Germany the employment rate of workers between 55 and 64 years reaches a level of about 45% in the year 2005 (see Figure A.1 in the appendix). Several studies show that compared to younger employees older workers are less likely and less qualified to use information and communication technologies (ICT) (e.g., de Koning et al. 2006, Schleife 2006). In an economy that is marked by rapid technological progress, the demographic development on the one hand and the relationship between older workers and ICT on the other hand provide a great challenge for the firms. Especially for firms belonging to ICT-intensive and human capital-intensive sectors an efficient relationship between these two factors is crucial for the successful development of those sectors.

In particular, this is the case for knowledge-intensive service providers (e.g., tax consultancy and accounting, architecture) and for information and communication technology service providers (e.g., telecommunication services, software and IT services). These sectors contribute to about 8% of the sales in the German economy (Statistisches Bundesamt 2006). These industries exhibit two main characteristics that have determined their economic performance. First, the structure, quality and organisation of human capital inside the firms are important aspects in the production of the services they provide. Second, they make an intensive use of ICT, relying on a continuous adoption of new technologies and software. Considering the previous empirical results concerning the relationship between older workers and ICT it can be hypothesised that firms of the mentioned industries engaging

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older workers are less likely to adopt new or significantly improved technologies than firms of these industries with a younger workforce.

This paper analyses this hypothesis by focussing on the relationship between the age structure of the workforce and the adoption of new technologies of ICT- and knowledge-intensive service providers. Thereby it takes into account other factors that may affect the likelihood of the adoption of new technologies or software. The analyses are based on a data set of 362 German firms from the IT-related services sector. The paper also analyses the robustness of the results by testing different specifications. The empirical results show that firms with a higher share of younger employees are more likely to adopt new technologies and the older the workforce the less likely is the adoption of new technologies. Besides the age of the workforce, the customer requirements and the introduction of product innovations also impact the adoption of new or significantly improved technologies and software.

Previous studies find a complementary relationship between the use of ICT and modern human resource practices, such as team work and performance-related wages (Bresnahan et al. 2002, Bertschek et al. 2004). This discussion is mainly related to decentralising organisational measures implying more involvement of employees in decision making processes and more responsibilities of employees. Furthermore, there is some empirical evidence that the share of older workers is lower in firms with applied innovative workplace practices (Beckmann 2001, Aubert et al. 2006). Therefore, the interaction of a change in the workplace organisation and the age structure of the workforce is analysed. The results exhibit that the age structure of the workforce should be accompanied by appropriate workplace organisation. Firms that flattened their hierarchies enhanced their teamwork and have a higher share of employees being younger than 30 years are less likely to adopt new or significantly improved technologies. By contrast firms that changed their workplace organisation and have a higher share of employees between 40 and 55 years are more likely to adopt new technologies. This result however only holds for some of the firms, depending on their predicted probability to adopt new technologies.

This paper is organised as follows. The second section reviews the background discussion in existing economic literature on the relation between older workers, ICT, technology adoption and workplace organisation. Subsequently follow a description of the used data, the 46th wave of the quarterly business survey among IT-related service providers conducted by the Centre for European Economic Research (ZEW) and some descriptive statistics. In the 4th Section the estimation strategy and the empirical results are presented. Section 5 concludes and gives an outlook on further demands on research.

2 Background Discussion

This paper focuses on the relationship between the age structure of the workforce and the adoption of new or significantly improved technologies or software in ICT- and knowledge-intensive service providing firms. Therefore it is related to several strands of the literature.

There is the literature on older workers and ICT. Furthermore, as the adoption of new technologies in the IT-related services sectors can be seen as a process innovation,[2] the literature on older workers and process innovations is also concerned. There are several studies using individual data that show that compared to younger employees older workers are less likely and less qualified to use ICT. Friedberg (2003) analyses the relationship between computer use at work and the age of the workers, using individual data on American workers in the year 1993. Her results reveal that workers younger than 60 years use a computer more often than workers older than 60 years. Using individual-level data from 1997 of German male workers Schleife (2006) finds that the probability of computer use among workers aged between 55 and 64 years is significantly lower than that of workers between 25 and 34 years. Borghans and ter Weel (2002) and de Koning and Gelderblom (2006) show in their analyses that the computer skills of younger employees are better than those of older workers. De Koning and Gelderblom (2006) additionally exhibit that the probability of using complicated ICT applications at work is lower among workers above 50 years. Other papers analyse the reverse effect, thus how the use of IT or the adoption of new technologies affect the share of older workers. Bertschek (2004) shows in her analysis with German firm level data that the higher the IT intensity, the lower the share of employees being 50 years or older. There is only weak empirical evidence for the opposite. Beckmann (2001) finds that a firm which has invested in IT leads to positive impacts on the employment of older workers. He measures ICT usage by using a dummy variable for ICT investments. This dummy variable, however, does not reflect to what extent the employees are affected by the corresponding investment in ICT.

The literature on the so-called age-biased technological change using firm-level data finds that technological progress negatively impacts the share of older workers or older low-skilled workers (Behaghel et al. 2007). Aubert, Caroli, and Roger (2006)

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2 According to the Oslo Manual (OECD, Eurostat 2005), "a process innovation is the implementation of a new or significantly improved production or delivery method". This includes significant changes in equipment, techniques and/or software (OECD, Eurostat 2005). The firms of these service industries are not inventing or creating new processes. As Hempell (2003b) states, the service providing firms especially those of the knowledge intensive branches rely on the inputs of the industry. So a process innovation is a change in the process of creating services caused by the introduction of new technologies or software provided by the industry or other service providers.

examine the impact of innovations on the wage-bill share of workers from different age groups in France. They find that the wage-bill share of older workers (aged 50 years and above) is lower in innovative firms, i.e., innovative firms tend to be biased against age. Beckmann (2005) finds that technological change has a negative impact on the share of older employees in West German firms. Schneider (2007) uses a linked employer-employee approach to analyse the impact of the age structure of the workforce on product innovations of German manufacturing firms. He finds significant effects of the age structure of the workforce on the technological innovativeness and an inverse u-shaped age innovation profile. There are only few empirical investigations that analyse the relation between process innovation and the age of the workforce in manufacturing firms. Rouvinen (2002) analyses the characteristics of product and process innovations in the Finnish manufacturing sector. He can show that an increasing average employee age, although he uses this variable as proxy for firm age, reduces the probability of process innovation. Another analysis that examines the relation between innovation and the age of the workforce is the one from Nishimura, Minetaki, Shirai, and Kurokawa (2004). They investigate the interaction between age and qualification of the employees and its impact on technological progress in Japanese industries. They only have a small sample and find no significant impact of old workers (above 40 years) with high qualification (share of old workers with high education to the total labour inputs) on the rate of technological progress in non-manufacturing industries. But they find that the share of old workers with high qualification in the 1990s reduces the rate of technological progress in the manufacturing industries.

The relationship between technological change and ICT on the one hand and older workers on the other hand is explained by two main hypotheses: (1) Using two data sets from the U.S., Friedberg (2003) states that the more infrequent use of computers amongst older workers is related to the imminent retirement. Investment in computer skills does not pay off any longer. She finds that computer users tend to retire later than non-users probably due to comparative advantages and because they are ready to invest in training. Furthermore, her results reveal that the more infrequent use of computers amongst older workers can be explained by the differences across occupations and education. Empirical evidence for Germany by Schleife (2006) suggests that age does not play a significant role for the retirement decision when controlling for other factors such as qualification, work experience, etc. Borghans and ter Weel (2002) even find that the imminent retirement of older workers is no significant parameter affecting the disuse of computers. The discussion about technological change and the retirement decision is related to the vintage human capital models (MacDonald et al. 2004). Within technological change and innovation human capital may become obsolete. So, older workers may offer resistance to innovation when their human capital might be ridden off. (2) Weinberg (2004) argues from a different point of view. He states that the ability to learn how

to use a computer declines with increasing age. This is in line with the so called "deficit-model" that explains the process of ageing from a gerontological point of view. This model assumes that older people compared to younger ones loose important features, they show defects and deficits. This affects physical (fading physical strength or decelerated reactions) and psychic skills (cutback of brainpower, especially of fluid brainpower which is the one needed amongst others for new solutions and a fast processing of information) (Börsch-Supan et al. 2005) as well as interests and social activities (Walter 1995) which are constricted. This can be referenced to the economic context and the labour market. Asked what kind of attributes emerge in which age group and how important those features are, personnel officers reply that skills like learning aptitude, willingness to learn or flexibility can be less found by older workers compared to younger ones (Boockmann et al. 2004). These skills, however, are especially important for the implementation of process innovation in terms of adopting new technologies or software.

There is a broad literature suggesting that the implementation of new IT systems often goes hand in hand with organisational changes in firms. Therefore, IT investment and organisational investment are interpreted as strategic complementarities (Brynjolfsson et al. 2000, Bresnahan et al. 2002, Bertschek et al. 2004). This discussion is mainly focussed on decentralising organisational measures implying more involvement of employees in decision making processes and more responsibilities of employees. Some examples are team work, flat hierarchies, autonomous working groups or incentive pay - measures supposed to positively affect the information flow within firms and the motivation of the employees. The use of innovative workplace practices such as teamwork and flat hierarchies (Gera et al. 2004, Webster 2004) may provide a better environment for the adoption of new technologies because of the existing complementarities (Milgrom et al. 1990, Hitt et al. 1997, Bresnahan et al. 2002). The implementation of a new information and communication or software system often requires restructuring of the firm to use the new system efficiently. Thus, it appears likely that workplace reorganisation has to be changed accordingly to make the operating process more efficient. But the other way round, it is also possible that the introduction or enhancement of teamwork and the flattening of hierarchies may have an impact on the probability of introducing new technologies or software.

Taking into account the complementary relationship between ICT and workplace organisation, there is also some empirical evidence on the relationship between older workers and organisational structures. These studies find that innovative workplace practices that give more decision-making authority and responsibility to employees is negatively related to the employment of older workers. Using West German firm level data for the years 1993 to 1995 Beckmann (2001, 2005) finds that organisational changes have significantly negative effects on the percentage share of workers aged 50 or older. Aubert, Caroli and Roger (2006) provide empiri-

cal evidence for France using linked employer-employee data. Their analysis show that the more innovative workplace practices are applied in the firm the lower is the percentage share of older workers. But not only the internal organisation may affect the probability to introduce new technologies or software also the external environment of the firm. The market and customers with their requirements (de Jong et al. 2003) and the competitive situation may result in the need to introduce new technologies or software to keep up with the surrounding development.

3 Data and Descriptive Statistics

The data used for the empirical analyses is taken from the quarterly business survey among IT-related service providers conducted by the Centre for European Economic Research (ZEW). The IT-related services sector comprises the information and communication technology service providers (enterprises of the branches software and IT services, ICT-specialised trade as well as telecommunication services) and knowledge-intensive service providers (enterprises of the branches tax consultancy and accounting, management consultancy, architecture, technical consultancy and planning, research and development as well as advertising). This study mainly uses the data of the 46th wave (3rd quarter 2005). The data set is designed as panel data. Some information have also been taken from the 45th, 48th and 49th wave. The final data set includes 362 firms.[3]

The adoption of new or significantly improved technologies and software is embodied by a dummy variable.[4] To analyse how the age of the workforce affects the adoption of new technologies or software, four age groups of employees that have been surveyed are used. In a second step, interactions between these age groups and a change in the workplace organisation are provided to test whether complementarities exist.[5]

Table 1 shows some descriptive statistics of the data, comparing those firms that adopted new or significantly improved technologies in the last twelve months to those firms that did not. Most of the employees are older than 30 years and younger than 55 years. About 57.6% of the employees of those firms that adopted new technologies are younger than 40 years compared to about 51.5% of the employees of the firms that did not adopt new technologies. The share of older workers is higher in firms that did not adopt new technologies. As Table 1 shows, about

3 For the composition of the used sample and further details see Table A.1 in the appendix.

4 The firms answered the following question: Did you adopt new or significantly improved technologies in the last 12 months?

5 A list of the variables used and some summary statistics can be found in Table A.2 in the appendix.

36% of the employees in firms not having adopted new technologies are between 40 and 55 years old compared to 32.8% of the employees of firms that adopted new technologies. The share of employees being 55 years and older is about 12.5% in the firms that did not adopt new or improved technologies compared to about 9.6% in the firms with technology adoption.

Comparing firms that adopted new or significantly improved technologies to those that did not adopt new technologies one can see that there is nearly no difference between them in terms of the share of highly qualified employees, in particular 37.9% compared to about 36.9% (see Table 1). This seems striking, as there has been a lot of discussion in the skill-biased technological change literature (e.g., Chennells et al. 2002, Card et al. 2002). They suggest that the use of new technologies and the diffusion of IT change skill requirements (Autor 2003, Spitz-Oener 2006) and thus lead to an increase in demand for highly qualified labour (see e.g., Falk (2002) for the case of Germany).

Table 1: Descriptive statistics

Descriptive statistics feature	Firms that adopted new technologies	Firms that did not adopt new technologies	Total sample
Share of employees below 30 years	24.9%	19.1%	22.1%
Share of employees between 30 and 40 years	32.7%	32.4%	32.6%
Share of employees between 40 and 55 years	32.8%	36.0%	34.3%
Share of employees above 55 years	9.6%	12.5%	11.0%
Share of highly qualified employees	37.9%	36.9%	37.4%
Flattening of hierarchies	34.5%	23.4%	29.2%
Enhancement of teamwork	48.5%	31.2%	40.2%
Changed customer requirements	80.0%	55.2%	68.2%
Foreign competitors	59.2%	46.6%	53.1%
Firm size (number of employees)	122.2	34.3	80.0
Exporters	35.7%	34.5%	35.1%

Source: ZEW, own calculations.

Table 1 reveals that amongst firms that adopted new technologies the share of firms whose workplace organisation changed (enhancement of teamwork and flattening of hierarchies) in the last three years is higher than amongst firms that did not adopt new technologies. On the one hand, this can be a signal for the generally higher

propensity to change and innovate in certain firms. On the other hand, it reflects the complementary relationship between ICT and workplace organisation.

More than half of the firms that adopted new technologies are competing with foreign firms, whereas this share is lower among the firms that did not adopt new or significantly improved technology, as Table 1 shows. About 80.0% of the firms that adopted new technologies report changed customer requirements in the last three years, just more than half of the firms that did not adopt new technologies had to face changed customer requirements.

The exporting activities between the two types of firms differ only slightly. About 35.7% of the firms that adopted new or improved technologies in the last twelve months are exporting services abroad, but only 34.5% of the firms that did not adopt new technologies are doing so. Moreover, larger firms are adopting new technologies rather than smaller firms. Those firms that adopted new technologies or software in the last twelve months have on average about 122 employees, whereas firms that did not adopt new technologies have only about 34 employees on average.

The descriptive analysis of the data also shows that the adoption of new or significantly improved technologies varies across industries. Firms belonging to the software and IT services branch are the ones that mostly adopted new technologies. About 65% of these firms introduced new technologies or software within the last twelve months. Firms belonging to the research and development sector, however, are rarely adopting new technologies, about 35% report to have adopted new or significantly improved technologies (see Figure A.2 in the appendix).

4 Empirical Analysis

4.1 Estimation Strategy

In the following, the hypothesis that firms with a higher share of older workers are less likely to adopt new or significantly improved technologies is analysed. The variable measuring the decision to adopt new or significantly improved technologies and software is a dummy variable and has the following form:

$$\text{technology adoption} = \begin{cases} 1 & \text{if the firm adopted technology,} \\ 0 & \text{if the firm did not.} \end{cases}$$

Thus, the impact of several independent variables on a dichotomous dependent variable will be examined.[6]

$$\text{prob(technology adoption} = 1) = F(\alpha + \beta\text{age} + \gamma X + \delta\text{controls} + \varepsilon) \qquad (1)$$

where prob(•) is the probability that a firm adopts a new or significantly improved technology, β is a coefficient vector that describes the impact of four different age groups of employees. The coefficient vector γ shows the effects of several other firm and market characteristics, δ represents a vector of coefficients regarding controls such as sector dummies and a dummy variable for East Germany and ε is the unobservable error term. A Probit model is used, assuming the error term ε is normally distributed.

The impact of each age group on the probability of adopting new technologies is estimated separately. Additionally, all four age groups are estimated altogether, taking the group of employees below 30 years as the reference group. To check the robustness of the results four different specifications are taken into account. In specification (1) besides the age structure and the controls, the share of highly qualified employees and dummy variables for the firm size are considered.[7] Additionally, in specification (2), the firm age, a dummy variable for exporting activity and a dummy variable for foreign competition are regarded. Older firms may be more traditional than their younger counterparts and therefore less inclined to change the operating process. Exporters may depend on the latest communication technologies in order to stay in contact with their customers abroad. In specification (3) dummy variables for changes in the workplace organisation (enhancement of teamwork and flattening of hierarchies) and a change in the customer and market requirements within the last three years are added. The share of employees working predominantly with a computer measures the IT-intensity of the firm. This share and a dummy variable for product innovation are additionally considered in specification (4). The introduction of a product innovation may lead to a change in the operating process and therefore to the adoption of new technologies.[8]

Taking into account the relationship between ICT and workplace organisation as well as between workplace organisation and older workers, in a second step, the interaction between the age groups and a change in the workplace organisation is taken into account. As the magnitude of the interaction effect in a Probit model

6 All calculations and estimations of this paper have been done with STATA 9.1.

7 Bigger firms may profit from emerging economies of scale.

8 Note however, that there may be some endogeneity problems. The age of the workforce may be endogenous, but at this stage it is assumed that the age of the workforce is a constant factor that doesn't significantly change within twelve months. Moreover, the dummy variable for product innovation may be endogenous, but the data doesn't provide appropriate instruments to control for this endogeneity.

does not equal the marginal effect of the interaction term, the method proposed by Ai and Norton (2003) and Norton, Wang and Ai (2004) is used.[9]

In a Probit model the magnitude of an interaction effect requires computing the cross derivative or cross difference of the expected value of the dependent variable. When one continuous and one dummy variable are interacted with each other the interaction effect is the discrete difference (with respect to the dummy variable) of the single derivative (with respect to the continuous variable). Using their method, the interaction effect is found by computing the cross derivatives (or differences). The standard error of the interaction effect is computed by applying the Delta method. The test for statistical significance has to be based on the estimated cross-partial derivative.

4.2 Results

The estimation results can be found in Tables A.3 to A.6 in the appendix. As the estimated coefficients in a Probit model only allow to make a statement on the significance and the sign of an effect, but not on the extent, only the marginal effects are discussed in the following. Table 2 reports the average marginal effects of the four age groups in the Probit estimations of the four different specifications. However, the results only reveal correlations and no causal relationships. It can be seen that firms with a higher share of employees being younger than 30 years have a higher probability to adopt new technologies, whereas firms with a higher share of employees being older than 55 years have a lower likelihood to introduce new or significantly improved technologies. The results also reveal that the older the workforce, the less probable the adoption of new or significantly improved technologies.

In particular, an increase in the share of employees below 30 years by one percentage point is related to an increase in the probability of adopting new technologies by 0.40 percentage points (see second column of Table 2, specification (1)). This result holds for all four specifications and the marginal effect lies between 0.40 and 0.53. This may be due to two reasons. Workers below 30 years have a high productivity and a high potential concerning the mastery of equipment and software (Tijdens et al. 2005). Moreover, the knowledge of this age group may still be up to date as their educational attainment has been achieved recently.

The likelihood of adopting new technologies and software is related to a decrease of 0.43 percentage points in the likelihood of adopting new technologies if the share of employees being older than 55 years increases by one percentage point

9 Only specification (4) is used to estimate the impact of the interaction effects between the age groups and the workplace organisation.

(see fifth column of Table 2, specification (1)). This finding is robust as the effect is valid for all four specifications. The marginal effect is between 0.43 and 0.51. There is also a negative relationship between the share of employees between 40 and 55 years and the likelihood of adopting new technologies although this effect is only significant in the second and fourth specification and even there only at the 10%-significance-level.

The last column of Table 2 contains the result of estimating all four age groups together. Compared to the share of employees below 30 years an increase in the share of employees being older than 30 years is related to a decrease in the probability of adopting new or significantly improved technologies, whereas the older the workforce the less likely is the adoption of new technologies or software. Table 2 shows that the probability to adopt new technologies is related to a decrease of 0.32 percentage points if the share of employees between 30 and 40 years decreases by one percentage point compared to the share of employees below 30 years (specification (1)). An increase in the share of employees between 40 and 55 years by one percentage point lowers the probability of introducing new technologies and software by about 0.34 percentage points (specification (1)). An increase in the share of workers older than 55 years by one percentage point, compared to the share of workers below 30 years, is related to a decrease of 0.62 percentage points in the likelihood of the adoption of new technologies or software (specification (1)). This result is robust as it holds for all four specifications.

An older staff hence is negatively related to the likelihood of introducing new or significantly improved technologies in the operating process. This is partly in line with the finding of Schneider (2007) who finds an inverse u-shaped age-innovation profile in the manufacturing sector. Furthermore, the results support the empirical evidence found by Rouvinen (2002) and Nishimura, Minetaki, Shirai, and Kurokawa (2004). They also find a negative influence of older employees on the (process) innovation probability in the manufacturing industries. This issue may be explained by two different hypotheses. Firstly, it may be that older workers have more problems to adapt to changes in the operating process, especially when they have a longer tenure. This is supported by the 'deficit-model' mentioned before and by the study of Morris and Venkatesh (2000). This effect could be boosted by the kind of changes if especially new technologies or software cause problems for older workers as stated by e.g., de Koning and Gelderblom (2006) and Schleife (2006) or Borghans and ter Weel (2002) who find that employees being older than 30 years have lower ICT-skills. Secondly, older firms which mainly employ older workers with longer job tenure may be more traditional itself and therefore less inclined to innovate or to change the working routine at all. This explanation, however, can be excluded, as the firm age is only to a certain extent related to the probability of adopting new technologies (see Tables A.4 and A.5 in the appendix).

Table 2: Marginal effects of Probit estimations

Variable	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)
		Specification (1)			
Share of employees below 30 years	0.399***				Reference
	(0.141)				categorie
Share of employees between 30 and 40 years		-0.005			-0.323*
		(0.141)			(0.174)
Share of employees between 40 and 55 years			-0.151		-0.339**
			(0.130)		(0.157)
Share of employees above 55 years				-0.429**	-0.617***
				(0.217)	(0.232)
		Specification (2)			
Share of employees below 30 years	0.478***				Reference
	(0.141)				categorie
Share of employees between 30 and 40 years		0.042			-0.345*
		(0.151)			(0.179)
Share of employees between 40 and 55 years			-0.242*		-0.446***
			(0.138)		(0.159)
Share of employees above 55 years				-0.514**	-0.715***
				(0.225)	(0.237)

Variable	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)	Marg. effect (Std. error)
		Specification (3)			
Share of employees below 30 years	0.446***				Reference
	(0.153)				categorie
Share of employees between 30 and 40 years		-0.011			-0.350*
		(0.156)			(0.192)
Share of employees between 40 and 55 years			-0.195		-0.407**
			(0.140)		(0.169)
Share of employees above 55 years				-0.507**	-0.714***
				(0.233)	(0.250)
		Specification (4)			
Share of employees below 30 years	0.531***				Reference
	(0.169)				categorie
Share of employees between 30 and 40 years		0.007			-0.405*
		(0.173)			(0.214)
Share of employees between 40 and 55 years			-0.235*		-0.512***
			(0.142)		(0.180)
Share of employees above 55 years				-0.486*	-0.745***
				(0.265)	(0.277)

Significance levels: * : 10% **: 5% ***: 1%.

Only in the last specification firm age has a positive significant effect on the likelihood of adopting new technologies for all age groups (see Table A.6 in the appendix). Firms that are older are more likely to adopt new or significantly improved technologies. One reason for this may be that newly founded firms start with the latest technology. Another reason could be that older firms have more capital and are therefore more likely to invest in new technologies.

Besides the age of the workforce the adoption of new or significantly improved technologies is simultaneously affected by some other factors. The analysis, however, reveals that not all of the variables controlled for are significant. It can be seen that the firm size positively affects the probability of adopting new technologies, although only in some specifications. Firms with more than nine employees are more likely to adopt new technologies (see Tables A.3 to A.6 in the appendix). This can be explained by emerging economies of scale: The larger the firm, the cheaper the introduction of new technologies or software per employee. Another point may be decreasing training costs, as the adoption of new technologies or software involves training requirements (Hempell 2003a).

Furthermore, changed customer requirements positively affect the probability of adopting new or significantly improved technologies. Firms that had to face changed market or customer requirements within the last three years are more likely to adopt new technologies (see Tables A.5 and A.6 in the appendix). This result seems plausible since the provision of knowledge-intensive services and ICT services comes along with a high degree of interaction with clients and customers respectively (Koch et al. 2006). On the other hand, the firms analysed in this study are mostly small- and medium-sized firms. De Jong and Brouwer (1999) find in their literature review that the customer information and a close cooperation with them is one of the main sources for (product) innovation in small- and medium-sized enterprises. As, especially in the service sector, a change in the operating process through new methods (in this case especially new information and communication technologies) may lead to improved services, the influence of the customer requirements is indispensable.

The enhancement of teamwork in the last three years as a tool of workplace organisation is positively related to the probability of adopting new technologies at the firm-level (see Table A.5 in the appendix). This is partly in line with empirical analyses that arrive at the conclusion that the workplace organisation matters in the context of innovation probability. Webster (2004) or Zoghi, Mohr and Meyer (2007) for example find that the extent of innovation, i.e., the probability of innovation, is higher in firms that have a stronger communication between management and workers or decentralised structures and information sharing. The same conclusions are drawn by Gera and Gu (2004), who show that measures beyond information-sharing programs like human resource management practices, including self-directed work groups (teamwork) significantly enhance the probability of introduc-

ing process innovations. However, the effect of enhanced teamwork turns to be insignificant if the dummy variable presenting product innovation is considered (see Table A.6 in the appendix). This suggests that in general innovative firms also tend to be innovative regarding their workplace organisation. The flattening of hierarchies however has no significant effect on the probability of adopting new technologies or software (see Tables A.5 and A.6 in the appendix).

The introduction of product innovations is positively related to the likelihood of adopting new technologies and software. Firms that offer new services are more likely to adopt new technologies (see Table A.6 in the appendix). On the one hand, this can be explained by a generally higher willingness of the firm to innovate or renew the operating process itself. On the other hand, in the services sector product innovations and process innovations cannot be distinguished easily. A process innovation as the adoption of new or significantly improved technologies allows to improve the quantity or quality of a provided service by keeping the input constant, reducing the supply costs or accelerating the process (Hempell 2003b). This change in the provided service caused by a process innovation is in turn interpretable as product innovation. The data do not offer appropriate instruments to control for endogeneity or simultaneity problems arising in this context.

Table A.7 in the appendix shows the interaction effects between changes in the workplace organisation and the share of employees belonging to one of the four age groups, their standard errors and their z-statistics, computed by the method of Ai and Norton (2003) and Norton, Wang and Ai (2004) instead of using the standard STATA output. The interpretation of the interaction effect is based on Figures A.3 and A.4 in the appendix, as the interaction effect, the standard errors and the z-statistic are calculated for each observation.[10] For each interaction effect two graphs are presented. The first graph plots two interaction effects (one is calculated by the method of Norton, Wang and Ai (2004) and the other one is calculated by the conventional linear method) against predicted probabilities and the second graph of each interaction effect plots the z-statistics against predicted probabilities.

As the upper left graph in Figure A.3 in the appendix shows, firms with a higher share of younger workers and an enhancement of teamwork in the last three years are less likely to adopt new technologies as firms that did not enhance teamwork. This effect is lower for firms whose probability to adopt new technologies or software is rather low or rather high in absolute terms and higher for firms whose probability to adopt new technologies or software lies between 0.2 and 0.8. The effect however is only significant for the latter firms, as can be seen in the upper right graph in Figure A.3. Regarding the interaction between the enhancement of teamwork and the share of employees between 40 and 55 years, the interaction

10 Only the significant effects are reported.

effect is reverse. Firms that enhanced teamwork in the last three years and have a higher share of employees between 40 and 55 years are more likely to adopt new technologies compared to firms that did not enhance teamwork. This effect is higher for firms whose probability to adopt new or significantly improved technologies is about 0.5 (see lower left graph in Figure A.3). Nevertheless, only few of the firms that have a predicted probability to adopt new technologies between 0.25 and 0.75 have statistically significant effects, as can be seen in the lower right graph in Figure A.3.

With respect to the flattening of hierarchies in the last three years, a similar picture is drawn. Firms that flattened their hierarchies and have a higher share of employees below 30 years are less likely to adopt new technologies compared to firms without a change in the workplace organisation. This effect is higher for firms whose predicted probability to adopt new technologies is around 0.5 and smaller for firms whose predicted probability is rather high or low, as we can see in the upper left graph in Figure A.4 in the appendix. But this effect is only significant for those firms whose predicted probability is between 0.15 and 0.85, as the upper right graph in Figure A.4 shows. The effect of the share of employees between 40 and 55 years in firms that flattened their hierarchies is also reverse. As we can see in the lower left graph in Figure A.4, firms that flattened their hierarchies and have a higher share of workers being between 40 and 55 years old are more likely to adopt new technologies and software than firms that did not flattened their hierarchies. This effect is higher for those firms whose predicted probability is around 0.5 and lower, for those whose predicted probability is rather low or high. Nevertheless, here the effect is only significant for some of those firms whose predicted probability is between 0.3 and 0.7 as the lower right graph in Figure A.4 shows.

The empirical results show that the age structure of firms has to be combined with appropriate workplace organisation in order to keep up with the technological development. A part of the firms with a higher share of younger workers and innovative workplace practices are less likely to adopt new technologies and some firms with a higher share of workers between 40 and 55 years and enhanced teamwork and flattened hierarchies have a higher probability to adopt new technologies. At first sight, this seems to contradict former empirical evidence from the manufacturing sector. It finds that workplace reorganisation is negatively related to the proportion of older employees in firms (e.g. Beckmann 2005, Aubert et al. 2006) and therefore suggests that older employees and innovative workplace practices are no suitable match. However, the results presented here are considering service sector firms instead of firms belonging to the manufacturing sector. The classification of the age groups differs. Beckmann (2005) or Aubert, Caroli and Roger (2006) find the negative effect for workers being 50 years or older whereas here it is the group of employees between 40 and 55 years that is positively linked with teamwork. Furthermore, firms that are very likely or very unlikely to adopt new technologies are

not affected by the joint impact of enhanced teamwork and workers being younger than 30 years or between 40 and 55 years respectively. And this is also the interesting point in this result. It suggests that only those firms that are not determined in adopting new technologies or in not adopting those from the beginning can increase their probability to adopt new technologies by taking the age structure and the appropriate workplace organisation in terms of teamwork into account. As technology adoption is a key factor in staying competitive the results suggest that firms with a high share of employees being younger than 30 years should abstain from enhancing teamwork or flattening hierarchies whereas firms with a high proportion of employees between 40 and 55 years should enhance teamwork or flatten hierarchies.

5 Conclusion

Due to the demographic development the workforce is getting older. As older people appear to be less likely and less qualified to use ICT, the age structure of the workforce may have an impact on the efficiency of the adoption of new or significantly improved technologies and software. In particular this may be the case for industries that are ICT-intensive and rely on the continuous adoption of new technologies or software.

Using a cross-sectional data set of 362 firms of the German ICT and the knowledge-intensive service providers in the year 2005 this paper finds that the age structure of the workforce is negatively related to the probability of adopting new or significantly improved technologies and software. Firms with a higher share of younger employees are more likely to adopt new technologies. This is in line with the literature that analyses the impact of the age of the employees on the probability of technological change and innovations in the manufacturing industries. The results reveal that firms with a higher share of employees being younger than 30 years have a higher probability to adopt new technologies, whereas firms with a higher share of employees being older than 55 years have a lower likelihood to introduce new technologies or software. After comparing the four age groups it becomes clear that the older the workforce, the less likely is the adoption of new technologies or software.

The use of innovative workplace practices may provide a better environment for the adoption of new technologies and the relationship between ICT and workplace organisation is complementary. Therefore, the interaction between the share of employees below 30 years and the share of employees between 40 and 55 years, the flattening of hierarchies and the enhancement of teamwork is analysed. The results exhibit contrary effects. Firms that flattened their hierarchies, enhanced their teamwork and have a high share of younger workers are less likely to adopt new

technologies than firms that did not change their workplace organisation. Firms that changed their workplace organisation and have a higher share of employees between 40 and 55 years are more probable to adopt new technologies compared to firms without workplace reorganisation. It seems that firms with a certain age structure of the workforce need appropriate workplace organisation to keep up with the technological development. This result, however, is only significant for some firms in the sample depending on their predicted probability to adopt new technologies.

Finally, the analyses show that there are further factors affecting the adoption of new or significantly improved technologies and software such as the change of market or customer requirements and the introduction of product innovation.

As the cross-sectional data offer no appropriate instruments to control for potential endogeneity of the age of the workforce as well as of the endogeneity of the introduction of product innovations, future research shall focus on this caveat. Analysing the relationship between the age structure of the workforce and the adoption of new technologies and software by using a panel data set could also help to control for unobserved heterogeneity in this context.

Appendix

The ZEW quarterly business survey in the German IT-related services sector includes the following industries (codes of the German Classification of Economic Activities, Edition 2003 in parentheses): software and IT services (71.33.0, 72.10.0-72.60.2), ICT-specialised trade (51.43.1, 51.43.3-3.4, 51.84.0, 52.45.2, 52.49.5-9.6), telecommunication services (64.30.1-0.4), tax consultancy and accounting (74.12.1-2.5), management consultancy (74.11.1-1.5, 74.13.1-3.2, 74.14.1-4.2), architecture (74.20.1-0.5), technical consultancy and planning (74.20.5-0.9), research and development (73.10.1-73.20.2) and advertising (74.40.1-0.2). Table A.1 shows, how the industries are distributed in the sample.

Table A.1: Distribution of industries in the sample Industry

	Percentage
Software and IT services	9.39
ICT-specialised trade	17.40
Telecommunication services	3.87
Tax consultancy and accounting	17.13
Management consultancy	8.56
Architecture	13.81
Technical consultancy and planning	11.88
Research and development	11.88
Advertising	6.08
Sum	100

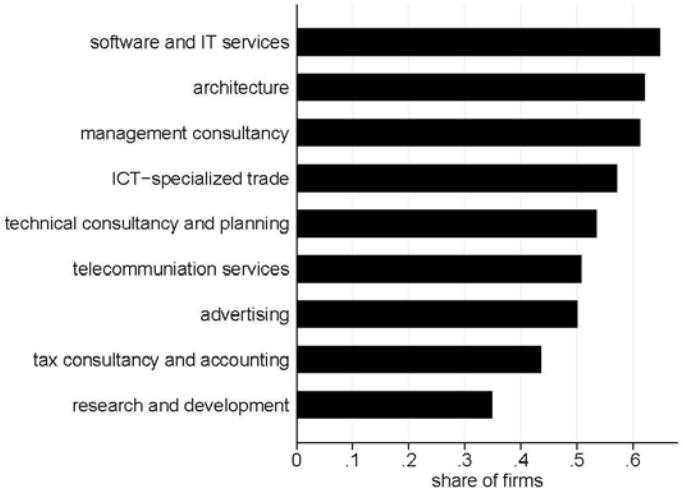
Source: ZEW, own calculations.

It contains mostly small- or medium-sized firms. In the composed sample the biggest firm has about 1,033 employees. The 46th wave of the survey, used here, includes information on the age structure of the workforce, the qualification level of the employees, the implemented process, product and organisational innovations, the export activity and foreign competitors. As the survey is constructed as a panel, gaps can be filled with data from other waves. The number of employees is created from the information on the age structure and the qualification level of the employees from the 46th wave. The information on the share of employees working predominantly with a computer (IT intensity) is taken from the 45th, 48th and 49th wave.

Figure A.1: Development of the employment rate of 55 – 64 years old workers

Source: Eurostat, Labour Force Survey.

Figure A.2: Share of firms that adopted new technologies by sector



Source: ZEW, own calculations.

Table A.2: Summary Statistics

Variable	Number of observations	Mean
Process innovation	362	0.5193
Product innovation	324	0. 5031
Share of employees below 30 years	362	0.2209
Share of employees between 30 and 40 years	362	0.3258
Share of employees between 40 and 55 years	362	0.3434
Share of employees above 55 years	362	0.1098
Share of highly qualified employees	362	0.3743
Enhancement of teamwork	326	0.4018
Flattening of hierarchies	325	0.2923
Customer requirements	324	0.6821
Firm size 1-9 employees	362	0.2790
Firm size 10-19 employees	362	0.2624
Firm size 20-49 employees	362	0.2127
Firm size more than 50 employees	362	0.2459
Firm age	356	16.0225
Foreign competitors	335	0.5313
Exporter	353	0.3513
IT intensity	362	0.7781
(Share of employees working predominantly with a computer)		
East Germany	362	0.2541

Source: ZEW, own calculations.

Table A.3: Results of Probit estimation (1)

Dependent variable: dummy for adoption of new technologies					
Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Share of employees below 30 years	1.033***				Reference
	(0.384)				categorie
Share of employees between 30 and 40 years		-0.014			-0.859*
		(0.367)			(0.469)
Share of employees between 40 and 55 years			-0.395		-0.901**
			(0.343)		(0.426)
Share of employees above 55 years				-1.129*	-1.642**
				(0.579)	(0.634)
Share of highly qualified employees	0.125	0.008	-0.002	0.005	0.102
	(0.270)	(0.268)	(0.267)	(0.267)	(0.273)
Firm size (dummy variable=1 if 1-9 employees)			Reference categorie		
Firm size (dummy variable=1 if 10-19 employees)	0.193	0.248	0.237	0.174	0.150
	(0.186)	(0.185)	(0.185)	(0.190)	(0.191)
Firm size (dummy variable=1 if 20-49 employees)	0.211	0.314	0.278	0.242	0.174
	(0.205)	(0.201)	(0.203)	(0.206)	(0.210)
Firm size (dummy variable=1 if 50 or more employees)	0.269	0.365*	0.334*	0.289	0.230
	(0.196)	(0.192)	(0.085)	(0.196)	(0.199)

Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
East Germany	-0.054	-0.078	-0.058	-0.075	-0.054
	(0.168)	(0.168)	(0.168)	(0.169)	(0.168)
Industry dummies jointly significant	no	no	no	no	no
Intercept	-0.536	-0.260	-0.122	-0.116	0.488
	(0.327)	(0.320)	(0.332)	(0.318)	(0.428)
N	362	362	362	362	362
Log-likelihood	-238.332	-241.862	-241.218	-239.871	-237.484
$X^2(14)$	24.227	16.457	18.053	20.503	
$X^2(16)$					25.357

Significance levels: * : 10% ** : 5% *** : 1% heteroscedasticity-robust standard errors.

Table A.4: Results of probit estimation (2)

Dependent variable: dummy for adoption of new technologies					
Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Share of employees below 30 years	1.230***				Reference
	(0.400)				categorie
Share of employees between 30 and 40 years		0.112			-0.945*
		(0.400)			(0.497)
Share of employees between 40 and 55 years			-0.648*		-1.221***
			(0.374)		(0.451)
Share of employees above 55 years				-1.380**	-1.957***
				(0.618)	(0.673)
Share of highly qualified employees	0.111	-0.082	-0.065	-0.077	0.053
	(0.307)	(0.304)	(0.304)	(0.302)	(0.310)
Firm size (dummy variable=1 if 1-9 employees)			Reference categorie		
Firm size (dummy variable=1 if 10-19 employees)	0.321	0.363*	0.362*	0.277	0.263
	(0.201)	(0.201)	(0.200)	(0.207)	(0.206)
Firm size (dummy variable=1 if 20-49 employees)	0.206	0.336	0.290	0.259	0.159
	(0.223)	(0.218)	(0.220)	(0.224)	(0.229)
Firm size (dummy variable=1 if 50 or more employees)	0.150	0.270	0.224	0.185	0.095
	(0.216)	(0.212)	(0.214)	(0.215)	(0.221)
Firm age	0.014*	0.011	0.013	0.013	0.015*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)

Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Exporter	0.008	0.023	0.042	-0.015	-0.007
	(0.171)	(0.168)	(0.170)	(0.170)	(0.173)
Foreign competitors	0.214	0.237	0.204	0.248	0.211
	(0.159)	(0.157)	(0.158)	(0.157)	(0.160)
East Germany	-0.133	-0.145	-0.121	-0.149	-0.124
	(0.188)	(0.188)	(0.188)	(0.189)	(0.189)
Industry dummies jointly significant	no	no	no	no	no
Intercept	-1.018*	-0.682*	-0.433	-0.505	0.231
	(0.393)	(0.378)	(0.385)	(0.373)	(0.469)
N	325	325	325	325	325
Log-likelihood	-208.922	-213.749	-212.313	-211.225	-207.758
$X^2(17)$	31.376	21.119	24.327	26.372	
$X^2(19)$					33.277

Significance levels: * : 10% ** : 5% *** : 1% heteroscedasticity-robust standard errors.

Table A.5: Results of probit estimation (3)

Dependent variable: dummy for adoption of new technologies					
Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Share of employees below 30 years	1.341***				Reference
	(0.474)				(categorie)
Share of employees between 30 and 40 years		-0.033			-1.059*
		(0.458)			(0.587)
Share of employees between 40 and 55 years			-0.573		-1.229**
			(0.416)		(0.524)
Share of employees above 55 years				-1.504**	-2.157***
				(0.701)	(0.776)
Share of highly qualified employees	0.235	0.058	0.054	0.026	0.174
	(0.345)	(0.337)	(0.341)	(0.337)	(0.347)
Firm size (dummy variable=1 if 1-9 employees)			Reference categorie		
Firm size (dummy variable=1 if 10-19 employees)	0.430*	0.457**	0.439*	0.376	0.373
	(0.234)	(0.231)	(0.234)	(0.239)	(0.237)
Firm size (dummy variable=1 if 20-49 employees)	0.332	0.455*	0.406*	0.400	0.304
	(0.251)	(0.244)	(0.246)	(0.249)	(0.254)
Firm size (dummy variable=1 if 50 or more employees)	0.059	0.156	0.100	0.074	0.005
	(0.245)	(0.236)	(0.241)	(0.239)	(0.250)
Firm age	0.014*	0.011	0.013	0.013*	0.015*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Exporter	-0.119	-0.102	-0.097	-0.151	-0.152
	(0.191)	(0.190)	(0.190)	(0.192)	(0.193)

Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Foreign competitors	0.194	0.227	0.198	0.225	0.191
	(0.179)	(0.177)	(0.179)	(0.176)	(0.180)
Flattening of hierarchies	-0.127	-0.149	-0.143	-0.159	-0.139
	(0.210)	(0.203)	(0.206)	(0.203)	(0.209)
Enhancement of teamwork	0.368*	0.413**	0.407**	0.448**	0.401**
	(0.194)	(0.193)	(0.192)	(0.188)	(0.195)
Customer requirement	0.800***	0.776***	0.778***	0.765***	0.789***
	(0.184)	(0.181)	(0.182)	(0.183)	(0.185)
East Germany	-0.053	-0.085	-0.071	-0.065	-0.039
	(0.210)	(0.209)	(0.208)	(0.212)	(0.210)
Industry dummies jointly significant	no	no	no	no	no
Intercept	-1.695***	-1.251***	-1.057**	-1.087**	-0.357
	(0.458)	(0.435)	(0.447)	(0.426)	(0.560)
N	283	283	283	283	283
Log-likelihood	-166.198	-170.153	-169.267	-168.1	-165.292
$X^2(20)$	62.115	50.623	51.726	56.919	
$X^2(22)$					63.911

Significance levels: * : 10% ** : 5% *** : 1% heteroscedasticity-robust standard errors.

Table A.6: Results of probit estimation (4)

Dependent variable: dummy for adoption of new technologies					
Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Share of employees below 30 years	1.757***				Reference
	(0.575)				categorie
Share of employees between 30 and 40 years		0.022			-1.347*
		(0.551)			(0.721)
Share of employees between 40 and 55 years			-0.755*		-1.702***
			(0.458)		(0.611)
Share of employees above 55 years				-1.565*	-2.475**
				(0.859)	(0.939)
Share of highly qualified employees	0.230	-0.040	-0.016	-0.080	0.142
	(0.426)	(0.410)	(0.414)	(0.409)	(0.430)
Firm size (dummy variable=1 if 1-9 employees)			Reference categorie		
Firm size (dummy variable=1 if 10-19 employees)	0.360	0.403	0.389	0.315	0.298
	(0.272)	(0.265)	(0.267)	(0.279)	(0.276)
Firm size (dummy variable=1 if 20-49 employees)	0.498*	0.626**	0.592**	0.572*	0.474
	(0.295)	(0.285)	(0.286)	(0.293)	(0.297)
Firm size (dummy variable=l if 50 or more employees)	0.070	0.185	0.145	0.111	0.027
	(0.295)	(0.285)	(0.289)	(0.289)	(0.298)
Firm age	0.020**	0.015*	0.017**	0.017*	0.021**
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)
Exporter	-0.071	-0.033	-0.039	-0.097	-0.114
	(0.219)	(0.216)	(0.216)	(0.220)	(0.221)

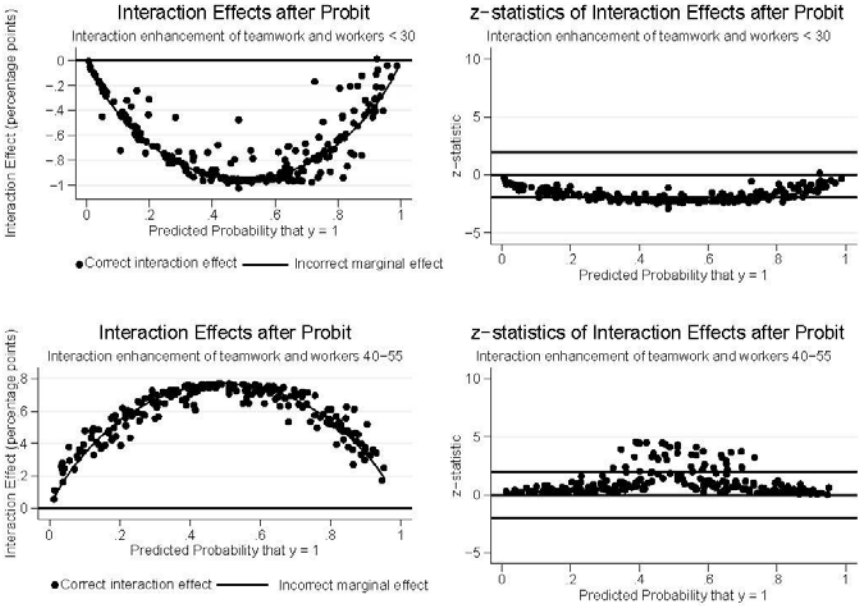
Variable	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)	Coefficient (Std. err.)
Foreign competitors	-0.024	0.027	-0.003	0.027	-0.026
	(0.214)	(0.208)	(0.213)	(0.208)	(0.216)
Flattening of hierarchies	-0.127	-0.131	-0.153	-0.159	-0.161
	(0.242)	(0.239)	(0.241)	(0.238)	(0.245)
Enhancement of teamwork	0.026	0.099	0.094	0.145	0.074
	(0.225)	(0.228)	(0.223)	(0.221)	(0.230)
Customer requirement	0.782***	0.685***	0.711***	0.672***	0.763***
	(0.217)	(0.217)	(0.220)	(0.217)	(0.220)
Product innovation	0.874***	0.858***	0.863***	0.840***	0.862***
	(0.209)	(0.207)	(0.208)	(0.207)	(0.209)
IT - intensity	0.155	0.258	0.212	0.263	0.162
	(0.380)	(0.367)	(0.362)	(0.374)	(0.381)
East Germany	0.100	-0.008	0.044	0.028	0.132
	(0.258)	(0.251)	(0.251)	(0.254)	(0.259)
Industry dummies jointly significant	no	no	no	no	no
Intercept	-2.135***	-1.595***	-1.313**	-1.358**	-0.363
	(0.598)	(0.573)	(0.571)	(0.584)	(0.722)
N	224	224	224	224	224
Log-likelihood	-120.598	-124.824	-123.702	-123.259	-119.972
$X^2(22)$	75.682	57.303	61.972	63.562	
$X^2(24)$					76.603

Significance levels: * : 10% ** : 5% *** : 1% heteroscedasticity-robust standard errors.

Table A.7: Interaction effects

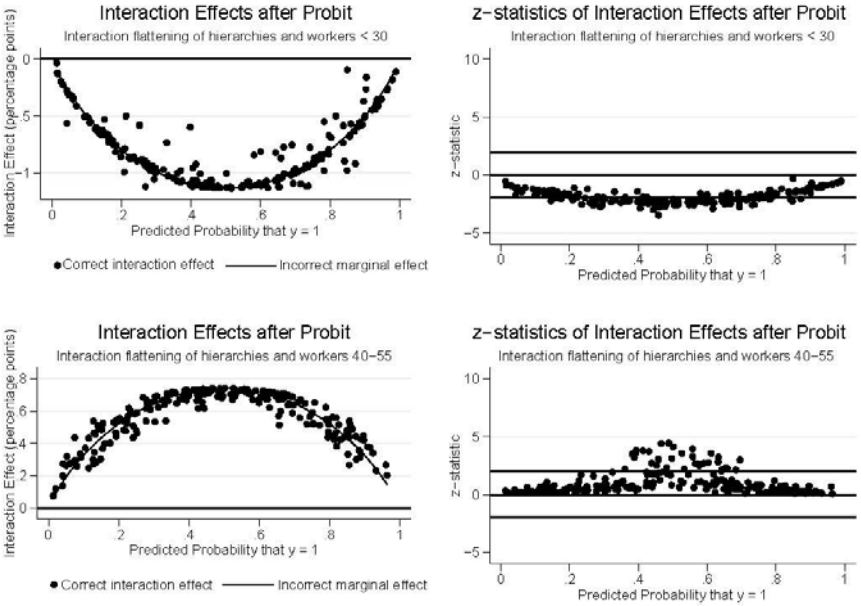
Variable	Mean Interaction effect	Mean Std. error	Mean Z-statistic
	Interaction with teamwork		
Share of employees below 30 years	-0.679	0.371	-1.735
Share of employees between 30 and 40 years	0.190	0.398	0.660
Share of employees between 40 and 55 years	0.595	1.097	1.102
Share of employees above 55 years	-0.369	1.002	-0.627
	Interaction with hierarchies		
Share of employees below 30 years	-0.825	0.428	-1.884
Share of employees between 30 and 40 years	0.042	0.165	0.263
Share of employees between 40 and 55 years	0.569	1.085	0.997
Share of employees above 55 years	0.334	0.755	0.727

Figure A.3: Interaction effects: enhancement of teamwork



Source: Own calculations based on estimation of specification (4), 224 specifications.

Figure A.4: Interaction effects: flattening of hierarchies



Source: Own calculations based on estimation of specification (4), 224 observations.

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III. Ageing & Innovation

Demographic Change and Industry-specific Innovation Patterns in Germany

Golo Henseke, Thusnelda Tivig

1. Motivation

Technological progress is the key determinant of economic growth in advanced economies. It consists of innovations and the knowledge needed to use them in production (Romer 1986, 1987). Innovations emerge from spontaneous or trained creativity, coupled with purposeful investment (R&D) and job-practice (learning-by-doing, Arrow 1962); they are thus based on knowledge and are producing new knowledge. People have different intellectual and institutional access to knowledge. The former refers to cognitive and motivational capacity; the latter encompasses access to (high-quality) schooling as well as to job practice and leading-edge technologies. Both result in heterogeneity of "human capital", defined as a worker's, firm's or nation's stock of embodied knowledge and economically useful skills. In the process of human capital accumulation, innate abilities reduce the cost of education and training in terms of own efforts and are believed to contribute to the development of talent. In Germany, talents or "high potentials" and generally "excellence" are currently considered particularly important for innovation and economic growth. This is in line with Southern et al. (1993) who note that: "When a nation feels that its standard of living is threatened, efforts to provide universal access [to education] may be traded off in favor of exploiting talent …" (p. 401).

In Germany, a thread to growth is perceived from demographic change. Demographic change means that a population is ageing with the perspective of shrinking. All developed countries experience increasing life expectancy leading to ageing. In some countries, altered demographic behaviour ("lowest-low fertility") adds the perspective of a shrinking population. In Germany, mortality rates have been higher than birth rates since the early 1970th, implying that each subsequent generation is smaller than the previous one and the proportion of the young population steadily falling. However, public concern is not only directed towards the size and the age structure of population, but also considers the quality of the labour force. The crucial question is whether an ageing and shrinking population has enough talents to sustain the innovation process which represents the basis of our prosperity. The topic of creative productivity has thus passed the border of psy-

chology and education literature into microeconomics and finally reached macroeconomics.

In this paper we only deal with productive creativity as manifested in innovations. Our basic interest is directed to age specificity of creative productivity. We pick up two simple questions, briefly dealt with in Henseke and Tivig (2005), too: What is the age distribution of inventors and how does it vary between different industries? We advance the hypothesis that creative productivity should depend on age in an industry-specific way and we test this hypothesis with European patent data for Germany. Additionally, we derive some tentative conclusions about the concentration of talent.

2. Data

In order to test our hypotheses we use cross-sectional data of inventors from an own survey of the Rostocker Zentrum. A questionnaire was sent to 2,293 German inventors whose patent application was published in 2003 at the European Patent Office in one of the following four fields: Agriculture and farm machinery, metallurgy, biotechnology and information technology. Out of the 2,293 questionnaires 381 were undeliverable while 410 returned filled in, which is a rate of return of 21%. The survey took place from August till November 2004. The advantage of patent data is that it allows collecting information about inventors, i.e., about people who do R&D at the technological frontier. We asked the patent applicants about sex, year of birth, year of first invention and first patent, respectively, year of last invention, the area of work and the total number of inventions over the career, so far.

The number of patents granted to a person, a firm, an industry or an economy is an indicator of inventive capacity; at the same time the aggregate number of patents issued in an industry or economy is widely accepted as a proxy for technical change (Griliches 1991). It is not a perfect indicator, though. Patented inventions are technical in nature; scientific discoveries and organisational innovations are not patentable. From patentable innovations roughly 80% are patented (Greif 1999). Between 1998 and 2000 around one third of German innovative companies used patents. Among bigger firms and in chemistry and machinery the share was higher (Ramer 2002). Unfortunately, we have no information about the value of the patents in our sample or about important individual characteristics like education. A more general difficulty arises from the classification system of patents. The international patent classification (IPC) is based on technical considerations. Linking it to an industry classification is not straightforward and the question arises whether a patent should be assigned to the sector where the product is produced or where the invention is used. We have not undergone the attempt to precisely match the used IPC to fitting industry sectors since our major interest is to identify differences in

the age bias of creative productivity depending on the pace of area-specific technological progress. However, we consider our biotechnology and information technology industries to be good approximations, whereas agriculture and metallurgy are only in a broad sense comparable to the economic sectors. The lack of a time dimension also causes difficulties, because we cannot distinguish between age and cohort effects nor do we know growth rates of the population of inventors. If the population of inventors had grown with a positive rate because R&D efforts were increased there would automatically be more young inventors. However, put apart all deficiencies, our data set still suffices to test our hypothesis.

3. Results

Before testing our hypotheses we take a quick look at some descriptive statistics. The mean age in the total sample is 45.9 years and the median is around 44 years, which is higher than the current median age in the work force and also higher than the forecasted value for 2050. The average age when the first patent was granted is 34.3 and the mean job tenure is 11 years while the median is around 7 years. As expected, the number of inventions is highly concentrated among inventors; the mean is almost 23 while the median is 10, which is a first sign of a right-skewed distribution. The variable for individual productivity that we use in this paper is the number of inventions per year as it seems more reliable than the unweighted number of inventions. The mean number of inventions per year is 2.13 and the median is 1.14. That means, more than half of the inventors in our sample are able to create more than one invention per year. The share of women in the data set is strikingly low (7.5 %) but consistent with the low proportion of women in technical study lines and occupations in Germany. Except for biotechnology, were women hold roughly 20% of inventions in our data set, their overall contribution would be negligible. Similar results are obtained by Giuri et al. (2005).

Hypothesis 1: Age Dependency of Inventive Productivity

Newton was 24 when he started to work at the theory of gravitation, Darwin was 29 when he developed his theory of natural selection, Einstein was 26 years old when he developed the special theory of relativity and Marie Curie was not older than 30 when she made her milestone discoveries in radioactivity. The general belief is that sciences and also engineering are a young people's game. If this was true, older societies would be less creative than younger ones. The same is largely believed about individual creativity over the life cycle. Over 100 years ago Beard described the inverse u-shaped distribution of scientific productivity over the lifespan for a set of "nearly all the greatest names in history". He concluded that ageing of a population could explain its "enormous stupidity and backwardness" (Cited after van

Dalen 1999). Empirical findings are quite robust over time. Cole (1979) found a slight age effect for a cross-sectional data set of academic scientists. Research output and research quality peak on average at age 40 to 44. Levin and Stephan (1991) report similar results, but for a panel data set of scientists. Van Dalen (1999) reaches comparable results for the Nobel Prize winners in Economics. He finds that 80% of the award-winning work has been completed before the age of 45. Stephan and Levin (1993) provide further empirical evidence for Nobel Prize winners, in general. Jones (2005) demonstrates a similar age effect for outstanding inventors. Lehman (1966) already reported a productivity peak between 35 and 39 for historical inventors in a variety of technological fields as well as for those still alive in the 1950s. Even before, Oberg (1960) tested the hypothesis of age-biased productivity on a sample of engineering employees. His results are ambiguous and support the importance of the particular field and task on the pattern of individual productivity: While R&D personnel's productivity peaks between 31 and 35 years, engineering employees are most valuable to the company between 51 and 60 years. Further empirical evidence for an age effect on innovative productivity is presented by Dalton and Thompson (1971) for a data set of around 2,500 engineers in the aerospace industry and technology-based commercial industries. Their measure of productivity is based on management's assessment. They report as well a fairly early age at which productivity peaks, namely between 31 to 35 years and presume that an increase in the importance of new knowledge sharpens the age dependency of inventive productivity. Finally, using the new PatVal data set (a large-scale cross-national survey for the EU), Hoisl (2005) also demonstrates that inventive productivity changes over the life cycle in terms of patent output.

In line with this literature, we expect to find an age effect, too. Concretely, we expect aggregate inventive productivity, measured by patenting, to be linked to active work age. Therefore and given the ever longer education periods in Germany as well as the fact that some working experience could enhance inventive abilities, we expect to find patent to be rewarded at age 30 to 60/65. Our results are as follows. Kernel density estimates of the inventors' age distribution yield a right-skewed distribution. The modal age is around 40, the median 44 and the mean at almost 46 years. These are definitely higher values than for the overall German workforce where the median was 40.2 years in 2005, but comparable to Hoisl (2005) who uses a much larger data set. Probably, successful innovators have an especially long educational period and/or need some kind of experience or job tenure for successful R&D. This is also stressed by the relatively high mean age of 34.6 years at which the first own patent was granted. But while the initial mean age does not significantly differ over sectors, it changes with age groups. In the group of young inventors ($\leq$35) the average age of the first patent is at around 29 years, whereas for older (50-65) and old (65+) inventors the measure is 37.3 and 39.7 years, respectively. The average number of patents per year in the total sample is 2.12. The measure is

higher for young inventors (2.9). Thereafter it decreases slightly, peaks again for the age group 55-65 (2.36) and drops to 1.3 for retired inventors. The values are significantly different at the 10%-level.

Hypothesis 2: Concentration of Genius

Apart from life cycle variations in creative productivity, the question was raised how productivity varies within a cohort. In a seminal paper Lotka (1926) describes that the vast amount of research is performed by a small minority of scientists. He describes the frequency distribution of scientific productivity by the equation: $y=x/n^2$, with x being the number of inventors with one invention, n the number of inventions and y the resulting number of inventors with n inventions. This equation is called Lotka's Law and it was extensively proved in the literature. Even though the exponent of n had been different in detail, the basic conclusion, that scientific productivity is highly concentrated, was generally confirmed. The conjecture is that, for various reasons, scientific productivity is path-dependent and determined by early success in research. Allison and Stewart (1974), Allison et al. (1982) and Cole (1979) formulate the Accumulative Advantage Hypotheses to further explain path dependency by relating to productivity as well as recognition.

In our data set there is a huge variation in the individual number of inventions, too, ranging from 1 to around 600. In order to control for job tenure and also to be able to select occasional inventors, we have weighted the number of inventions by job tenure. The resulting variable still varies impressively between individuals from almost zero to around 23 innovations per year. The median inventor in the data set is able to generate on average 1.2 inventions per year while the top 10 percent of inventors produce at least four times as many and the top 1 percent even around twelve times more inventions per year than the average. Hence, inventors are not a homogenous group. Testing Lotka's Law and thus our hypothesis, we confirm that many inventors contribute only occasionally to the creation of patents, while a small minority is highly productive. Consequently, if the distribution of talent in the population remains stable the number of highly creative and inventive individuals will decrease with demographic change.

Hypothesis 3: Sector-Specific Age Dependency of Innovations

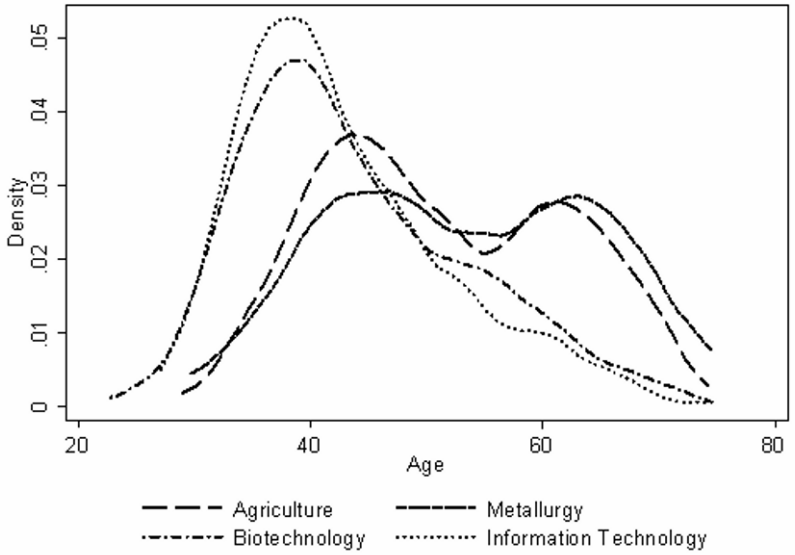
The driving force behind collecting our survey data was to test the industry specificity of the age distribution of inventors. Our intuition was fed by an analogy with science: Younger researchers are more successful in processing and recombining information, as it is the case for instance in mathematics, and older researchers are superior in experience- and reflection-based fields like philosophy.

We transformed these facts into economic terms and formulated our hypothesis: The age pattern of inventive productivity changes with the rate of technological change and consequently with the weights of experience versus new knowledge.

Since new knowledge is almost exclusively acquired in young ages, we expect younger, recently trained inventors to be more productive in sectors where the importance of new knowledge exceeds that of experience. In experience-based sectors, in which technological change is slower and more incremental in nature, older, more experienced inventors would have a comparative advantage over younger ones.

In order to test our hypothesis three empirically based regimes of technological change have been defined according to the R&D intensity: low-tech, high-tech and advanced-tech with an increasing pace of technological development over the categories. The classification of our sectors was done with help of the Fraunhofer Institut für System und Innovationsforschung. Agriculture is mainly low-tech, though some areas belong to high-tech industries. The same applies for metallurgy. On the other side there are biotechnology and especially information technology that are dominated by advanced-tech and high-tech products. In other words, the rate of technological change is higher in biotechnology and information and communication technology (ICT) compared to agriculture and metallurgy and therefore the age of inventors should be lower in the first group of industries. A quick look at sector-specific average ages already confirms that sectors may be grouped according to our hypothesis. In agriculture, the mean age is 51.4 which is very close to the value in metallurgy of 53.2 years. Contrary to that, in biotechnology and ICT, the mean ages are 43.9 and 42.9 years, respectively. As age is not normally distributed in some of the industries, we performed several non-parametric tests to verify that age distributions differ significantly between industries. The results obtained confirm that agriculture and metallurgy are different from biotechnology and information technology, whereas there are no significant differences within the low-tech group and the high-tech group. In Figure 1, kernel density estimates of the sector-specific age distributions are plotted to underline the statistical results graphically.

Figure 1: Kernel Density Estimates of sector-specific Age Distributions



4. Econometric Results[1]

Some results reported above can also be found in Henseke and Tivig (2005). To get deeper insights into the industry specificity of the age-innovation profiles, we additionally performed an econometric analysis. The general finding in the literature is that productivity follows an inverse u-shaped pattern over the professional career, with a sharp increase in the beginning followed by a peak and thereafter a gradual decline that might also stabilise at higher ages. This pattern can be described by a polynomial function of third degree. Age is the independent variable in the estimation. The dependent variable should ideally be individual productivity, but since we cannot measure it directly, we use the relative frequency of one-year age groups instead. The estimating equation is:

1 We would like to thank Carsten Ochsen for his very helpful suggestions concerning the econometric modelling strategy. All errors are our own.

$$p_i = \alpha + \beta_1 age_i + \beta_2 age_i^{\,2} + \beta_3 age_i^{\,3} + e_i \qquad (1)$$

with age_i as the i^{th} age group and p_i as the corresponding relative frequency. If inventive productivity is inverse u-shaped and the model fits the data, we expect that β_1 and β_3 have positive sign while β_2 is expected to have a negative sign. The model is estimated with OLS, first for the whole sample and then for each of the four sectors separately. White correction of standard errors is used, if necessary. The results are presented in Table 1.

Table 1: Estimation Results Model 1

Variable	Agriculture	Metallurgy+	Biotechnology	Information technology+	Total+
C	-.661608	.808968***	-.589990***	-.6383***	-.447869***
	(.445788)	(.174771)	(.103077)	(.1307)	(.051310)
Age	.040557	-.049236***	.042054***	.0447***	.031071***
	(.026439)	(.010755)	(.006755)	(.0084)	(.003337)
Age²	-.000754	.001023***	-.000881***	-.0009***	-.000631***
	(.000515)	(.000214)	(.000144)	(.00002)	(7.09E-05)
Age³	4.56E-06	-6.84E-06***	5.78E-06***	5.87E-06***	4.02E-06***
	(3.29E-06)	(1.38E-06)	(1.00E-06)	(1.22E-06)	(4.91E-07)
R^2	.061746	.276353	.505581	.424458	.628052
Adj. R^2	.003105	.237586	.493220	.413173	.625183
F-statistics	1.052948	7.128608	40.90297	37.61217	218.9480

+ white standard errors to correct for the influence of heteroskedasticity.
*** coefficient is significant at the 1%-level.

The model is able to explain a substantial part of the variability of data in the total sample, adjusted R^2 is 62.5% and all coefficients are significant at the 1%-level and have the expected signs (column 5). The estimation output displays, however, that the age distribution varies across industries. The estimated coefficients are different and also the overall fit of the model changes. For agriculture (column 1) the model is not able to explain the variation in the data, all coefficients are highly insignificant even though they have the expected sign; the R^2 is very low and consequently the F-

statistic is insignificant. Metallurgy (column 2), that appeared comparable to agriculture from the previous test, show a different pattern. The coefficients are all highly significant but have "wrong" signs. No more than one quarter of the whole variation in the data can be explained by the model used. The estimation results for biotechnology and information technology are firstly, similar to each other, confirming results of previous tests. In both cases coefficients are all significant, have the expected signs and are in both sub-samples very close to each other. The model fit is thus much better than in the other group of industries.

From the estimated coefficients it is possible to calculate the peak of each age distribution. As expected, the peak ages in biotechnology and information technology are very close to each other, 38.3 and 39 years, respectively. In agriculture the calculated peak is at 46.6 years, but the value is unreliable, because of the highly insignificant coefficients. For metallurgy, the calculated peak age is very high at 59 years which is caused by the estimated pattern. So, estimation results generally confirm our previous findings: Biotechnology and information technology are comparable in their age distribution to each other but are different to metallurgy and agriculture. However, for agriculture and metallurgy Model (1) is not appropriate since the variation in the age distribution cannot be explained and coefficients do not show the expected signs, respectively.

Therefore, in a next step we formulated an empirical model that allows estimating all sector-specific age distributions jointly in order to test differences between the estimated frequency distribution of age. The following specification was used:

$$p_{ji} = \alpha + \beta_{1j} age_{ji} + \beta_{2j} age_{ji}^{2} + \beta_{3j} age_{ji}^{3} + e_{ji} \qquad (2)$$

with age_{ji} as the i^{th} one-year age group in sector j and p_{ji} as the corresponding sector-specific relative frequency. Sector dummies are used to model varying response parameters. Model (2) is estimated by OLS with White's heteroskedasticity-consistent standard errors. As before, the expected signs of β_1 and β_3 are positive and of β_2 negative. The results can be found in Table 2 below. In the first two columns the sector-specific frequency distribution of age calculated from the sample is used as a dependent variable. To eliminate a part of the randomness in the data and to check the robustness of the results in column 1 and 2, five-years moving averages of the age density are used in column 3 and 4. According to our hypothesis 3 we divide sectors into a low-tech and a high-tech group (column 1 and 3). The results are compared with the estimation of the full set of sector dummies (column 2 and 4). If our hypothesis is true, the coefficients and the overall quality of the estimations will not differ between the two specifications. Furthermore, the specification allows using the Wald-Test to test for significant differences between the estimated

age density patterns. Therefore, we impose restrictions on the coefficients, namely that they are equal. If the restrictions are true, then the unrestricted estimates will be similar to the restricted ones and the Wald-Test statistic does not reject the null hypothesis of equal age patterns.

The reference sector is information technology (the high-tech group), because the number of observations is the highest. Generally, the model fits the data fairly well. All coefficients have the expected signs and the adjusted R^2 ranges from 24.7% for sample data to 58.8% when the age distribution data is smoothed. For an interpretation of the results remember that the estimated coefficients in the upper rows are valid for the reference group. To calculate the values for another sector or group, simple add the coefficients of the interaction variables. Insignificant coefficients of the interaction variables indicate that the age distribution of the specific sector is not statistically different from the reference category. In column 1 all estimated values are significant for the basic model itself as well as the interaction variables. Thus, there are significant differences in the sample between the age distributions in high-tech and low-tech industries. As before, we calculate the peak age which is 39.4 and 46.9 years for high-tech and low-tech industries, respectively. The adjusted R^2 is with 26.6% relatively low which might be caused by the high randomness in the data and the small sample size. In column 2, the whole set of sectors is used: Compared to column 1 the adjusted R^2 declines. The newly added sector variables have no further explanatory power which is in accordance to the hypothesis. With the exception of the biotechnology interaction variables, all coefficients are significant at least at the 10%-level. The estimation of the reference model is very close to results in column 1. Biotechnology does not differ significantly from the reference category while agriculture and metallurgy do. The resulting peak age for information technology is 38.6 years, for biotechnology 40.1 years, for metallurgy 48.1 years and for agriculture 47.4 years. We again use the Wald-Test to confirm that the estimated age distributions are different from each other. The results strongly confirm our hypothesis: Biotechnology and information technology, on one side, and agriculture and metallurgy, on the other side, differ from each other, while no such differences can be found within the groups. Finally, in the last two columns of Table 2 we report the results with the moving average of relative age frequencies as the dependent variable. Smoothing and reduction of randomness clearly have a positive impact on the estimates and further support our previous findings. The adjusted R^2 is in both columns around 60%. Again, the use of the whole set of sector dummies adds only marginal explanatory power as compared to the low-tech dummy estimation. In column 3 all coefficients are significant and have the expected signs. As before, the estimated age density distributions in low- and high-tech industries differ significantly from each other. Findings in the last column are generally in line with our hypothesis.

Table 2: Estimation Results for Model 2

Variable	Sample Age Density 2 groups	Sample Age Density all sectors	MA Age Density 2 groups	MA Age Density All sectors
C	-.446610***	-.424128***	-.527597***	-.494007***
	(.084959)	(.098758)	(.071038)	(.071413)
AGE	.030763***	.030097***	.036190***	.035151***
	(.005399)	(.005947)	(.004437)	(.004312)
AGE²	-.000618***	-.000614***	-.000734***	-.000728***
	(.000108)	(.000116)	(8.94E-05)	(8.53E-05)
AGE³	3.85E-06***	3.87E-06***	4.65E-06***	4.67E-06***
	(6.96E-07)	(7.30E-07)	(5.83E-07)	(5.50E-07)
(Age·lti)	-.004542***		-.004889***	
	(.001298)		(.000873)	
(Age²·lti)	.000152***		.000162***	
	(4.74E-05)		(3.32E-05)	
(Age³·lti)	-1.20E-06***		-1.26E-06***	
	(4.19E-07)		(3.07E-07)	
(Age·b1)		-.005397***		-.005574***
		(.001566)		(.001337)
(Age·b2)		-.005154**		-.006318***
		(.002243)		(.001142)
(Age·b3)		-.001140		-0.001521
		(.001353)		(.000939)
(Age²·b1)		.000185***		.000189***
		(5.78E-05)		(5.14E-05)
(Age²·b2)		.000170**		.000208***
		(8.13E-05)		(4.30E-05)
(Age²·b3)		3.70E-05		4.96E-05
		(4.86E-05)		(3.40E-05)
(Age³·b1)		-1.50E-06***		-1.52E-06***
		(5.17E-07)		(4.81E-07)
(Age³·b2)		-1.31E-06*		-1.61E-06***
		(7.11E-07)		(3.91E-07)
(Age³·b3)		-2.82E-07		-3.82E-07
		(4.27E-07)		(3.02E-07)
R^2	0.291822	0.299748	0.593326	0.619532
Adj. R^2	0.266225	0.247229	0.577059	0.587826

*** coefficient is significant at 1% level.
** coefficient is significant at the 5% level.
* coefficient is significant at the 10% level.

lti – dummy for low tech industries. (agriculture, metallurgy).
b1 – dummy variable for agriculture.
b2 – dummy variable for metallurgy.
b3 – dummy variable for biotechnology.

First, the adjusted R^2 changes only slightly as compared to the previous column. Second, agriculture and metallurgy do not differ from each. But even though single estimates of biotechnology are not significant, the age density distribution of biotechnology as a whole is now significantly different from the one in information technology at the 1%-level. The linear part is still equal, but the quadratic and cubic terms differ. However, differences between high- and low-tech industries regarding calculated peak ages last. In ICT the peak age is 38.1 years, in biotechnology it is 39.8 years while in metallurgy and agriculture it is 48.4 and 45.9 years, respectively. A summary of the calculated maxima and minimum ages based on the estimates of Model (1) and (2) can be found in Table 3. Interestingly, the calculated minimum age is sector-independent and varies around the onset of retirement; this can be seen as a further proof of the reliability of our results. Furthermore, it allows to conclude that there is a non-negligible amount of inventors who (re)start patenting after retirement.

Table 3: Maxima and Minima of the Estimated Age Density Functions

Model (1) Separate estimation		Total	Agriculture	Metallurgy	Biotech	ICT
Maximum at age		39.63	46.56	59.13	38.31	38.95
Minimum at age		65.02	63.67	40.58	63.3	65.19
Model (2) Joint Estimation Original Data	High-tech	Low-tech	Agriculture	Metallurgy	Biotech..	ICT
Maximum at age	39.38	46.88	47.43	48.09	40.07	38.58
Minimum at age	67.63	70.35	73.25	67.53	67.14	67.19
Model (2) Joint Estimation Smoothed Data	High-tech	Low-tech	Agriculture	Metallurgy	Biotech	ICT
Maximum at age	39.42	46.99	45.93	48.41	39.82	38.14
Minimum at age	65.82	65.5	68.14	64.88	65.65	65.79

5. Summary and Conclusion

In this paper we briefly review why ageing is believed to diminish creative productivity on all levels, thus threatening welfare in advanced industrial countries. Then we picture and analyse in great detail the age structures of German inventors as identified by patents granted by the European Patent Office in the year 2003. As no age variables are contained in patent descriptions, we conducted an own survey. Its size was limited by available means. At that time we were not aware of parallel ef-

forts conducted on a much lager scale with the PatVal survey for the EU. However, our main question could not be dealt with PatVat data, so far.

We test three hypotheses concerning: Age dependency of productive creativity (Hypothesis 1), concentration of talent (Hypothesis 2) and industry specificity of age dependency of innovations. Concerning the first two hypotheses, we essentially confirm the results of other studies based on very different data sets. Yet, by interpreting the results from the perspective of demographic change, we draw attention to some aspects not considered before. For example, the median age of our inventors is much higher than for the overall German workforce. Possible reasons were named before: long education periods, some other institutional factors as well as the need to gain some experience before contributing to own patents. Consequence of this finding is that ageing in Germany does not seem, at least at present and for a while, that detrimental to creative productivity as currently assumed. However, under Hypothesis 2 we tested Lotka's Law and found that many inventors contribute only occasionally to the creation of patents, while a small minority is highly productive. Assuming that the distribution of talent in the population remains stable, the number of highly creative and inventive individuals will decrease with demographic change.

Our original hypothesis, inspired, of course, by a whole bunch of literature in fields ranging from psychology and education to the economics of innovation and growth theory, is Hypothesis 3. Beside some descriptive statistics we run several econometric regressions to test our conjecture that creative productivity is industry-specific, because it depends on technological change, that differ itself across industries. We look at four fields: Agriculture and farm machinery, metallurgy, biotechnology and information technology, which we group into "low-tech" (the former two) and "high-tech" industries (the latter two). Our results support the conclusion that in innovative and hence fast growing sectors with high rates of technological change younger inventors perform better while older ones have a comparative advantage in fields with slower technological change, where knowledge has a lower half-time and experience faces a higher value.

Currently the baby boomer cohorts are aged 35 to 44 and contribute almost one third to the labour force. There is a large supply of educated and talented individuals from which the German economy benefits in terms of innovations, technological progress and productivity. Additionally, the German economy currently draws substantial power from the export of goods that are to a large extent experience-based, too, like automobiles. In 2050 the size of the age group 35 to 44 will have declined by 4 million persons compared to 2003 according to a rough projection of the Rostocker Zentrum (2005). Their share in the labour force will be around 25% or even lower, if labour force participation rates of older workers increase. The question that arises here is: Will the talents suffice to keep the German economy at the technological frontier with more and more knowledge-intensive

inventions and hence growing demand for young inventors? Fortunately, there are ways out of any scarcity once it is recognised.

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Age, Human Capital and the Geography of Innovation

Katharina Frosch, Thusnelda Tivig

1. Innovation in Times of Demographic Change

Policy-makers and business leaders are currently trying to assess the issue of demographic change and how, and to what extent innovative activity depends on the age structure of the labour force. Motivated by this increased public interest, a number of studies[1] analysing the age dependency of patenting output have been conducted. So far, empirical evidence tells us that innovative activity, as measured by patenting, starts at around 30 years, rises until a period of maximum productivity and slowly declines around age 50. Furthermore, the age, when maximum performance is reached, differs across industrial sectors. These findings are in line with earlier, well established evidence provided by industrial and organisational psychology (I-O psychology) which found that creative performance declines over one's life course. However, creative performance peaks at very different ages depending on the domain (Simonton 1988).

The novelty of our analysis resides in three major points. First, we advance the hypothesis that, to determine a broader effect of age on patenting performance, the age structure and the stock of human capital of the total labour force have to be considered. In the previously mentioned studies (see footnote 1) only the age distribution of already successful inventors is taken into account. Due to a lack of age information in existing patenting data sets, we therefore suggest to use the Griliches-Jaffe (regional) knowledge production framework to link age information about the *total* labour force and patenting performance. Second, inspired by Sturman (2001), we believe that simply including age as a variable takes too narrow a view of the effect age has on innovative performance within a firm, an industry or a region. We propose instead to distinguish two channels through which the age of workers influences innovative performance: the stock of age-specific human capital

1 Jones (2005) provides age-performance profiles for great inventors the US. Hoisl (2007) as well as Henseke and Tivig (2007) work on the age dependency of patenting activity in Germany. However, at the moment, these results are not yet published in reviewed journals but only available as working papers.

and an independent age effect which directly results from the age structure of the labour force.

The rest of the chapter is organised as follows. In Section 2, we advance some theoretical considerations about age-heterogeneous human capital and a possible human capital independent age effect on innovative performance. In Section 3, we present empirical evidence, based on the regional knowledge production framework suggested by Griliches (1979), and extend it to encompass age-specific human capital and an independent age effect. Section 4 concludes with a short summary and perspectives for future research.

2. Independent Age Effect and Age-specific Human Capital

2.1 Age-specific Human Capital

New technological achievements require the stock of human capital to be close to the existing technological frontier (Evenson et al. 1976, Kortum 1997). According to Kortum (1997), the probability that a novel contribution emerges is negatively related to the gap between the stock of human capital and the technological frontier. This is because technological change decreases, ceteris paribus, the potential of human capital for innovation. This effect becomes most obvious for knowledge acquired through formal schooling, and is sometimes denoted as the half-time of knowledge.

One way of overcoming this problem is human capital accumulation. The question that arises here for this chapter is: How does human capital accumulation relate to age? Previous theoretical and empirical research provides evidence that the rate of human capital accumulation is lower for older workers than for younger workers. This results in a clear disadvantage for older workers with respect to innovative potential. These disadvantages arise in a number of ways. For example, private companies provide much shorter formal training courses for older compared to younger workers (Asplund 2005). For costless learning-by-doing (Arrow 1962), pay-off periods do not play a role. However, older workers are less likely to be placed in domains close to the technological frontier and they are usually placed in less productive jobs (see e.g. Friedberg 2001). This clearly reduces the opportunity for older workers to accumulate innovation-relevant human capital through learning-by-doing. Finally, given that learning capacity is found to decline with age (Verhaegen et al. 1997), the same amount of formal training would lead to less growth in human capital for older workers compared to younger workers. All in all, the accumulation rate of innovation-relevant human capital is lower for older than for younger workers, and given that human capital obsolescence increases with age, one

can assume a double-negative effect of age on the innovative potential of human capital.

2.2 Independent Age Effect

Economics provide valuable models for the analysis of human capital accumulation and depreciation. Industrial and organisational psychology (I-O psychology) adds some dimensions to these considerations. Many economic studies analysing age-productivity profiles emphasise the influence of age-dependent psychological processes such as the decline in fluid and the increase in crystalline capacity with age (e.g. Ilmakunnas et al. 2004: 251). Further research also found that life time development has a significant impact on motivation (e.g. Sturman 2001: 613). However, none of these findings is integrated into an economic model. The decline in general mental ability or motivation is only indirectly considered in the econometric model by using age indicators and/or general human capital indicators depending on tenure or work experience. This is a point where I-O psychology can substantially contribute to previous findings, by offering some notable conceptualisations and providing extensive empirical evidence about the effect of factors such as the ability to exploit one's abilities or achievement motivation on performance over the life course. We will go through both factors below.

With regard to the exploitation abilities, Simonton (1988) shows through chance-configuration theory that the emergence of innovative achievements does not only depend on the creative potential, but also on the capacity to exploit it. There are a number of steps in the process. In a first step, so called 'ideations' lead to specific chance configurations of a fixed number of mental elements given by the initial creative potential. The second step, 'elaboration', leads to the implementation of ideations and hence to concrete innovations. Previously, economists have rejected the abstract notion of a total-life span creativity and instead follow the idea of age-specific human capital. However, it is intuitive that innovative output also depends on exploitation ability. If creative performance does follow this double-exponential process of ideation and elaboration, as suggested by Simonton (1988), innovative output starts to decline from a certain age onwards even if human capital was assumed to be homogeneous with respect to age[2].

2 And indeed, the deficit theory of ageing suggests that increased age causes deterioration in physical and cognitive abilities (for a review see Sturman 2003). Meta-analytic results by Verhaegen and Salthouse (1997) show that reasoning, speed and episodic memory decline significantly by the age of 50. Kanfer and Ackerman (2004) state that there are abilities that decline (i.e., fluid intelligence) and abilities that increase (i.e., crystalline intelligence due to expertise) over the life span. The decline in fluid capacity could affect the ability to recombine knowledge, hence, negatively influence ideation rates.

With regard to motivational factors, Kanfer and Ackerman (2004) present a comprehensive framework for the life-span evolution of motivation. They state that neither psychological theory nor empirical evidence can prove a general decline in work motivation caused by age. However, combined with other factors, such as work environment and the prevailing incentive systems, age-related changes may very well lead to decreased work motivation. This conjecture is supported by a number of studies, economic ones included. For example, Gibbons and Murphy (1992) find that older workers show a higher level of intrinsic motivation than their younger counterparts who are still driven by career concerns. Another aspect is the functional relationship between effort and utility corresponding to what Wright and Hamilton (1978) refer to as 'grinding down': Older persons accept age-induced restrictions in resources and abilities, i.e., that the same effort leads to less utility and consequently older workers lessen their expectations. On this basis, Kanfer and Ackerman (2004) infer an overall hump-shaped relationship between age and motivation. Motowidlo (2003: 50) considers motivation as a moderating factor influencing the effect of other variables on human performance. Thus, these findings from psychological theory and empirical findings suggest that there is an independent age effect on performance besides human capital effects.

3. Empirical Analysis

Model The main objective of this study is to estimate the effect of age on innovative performance on aggregate level for German districts. The knowledge production function suggested by Griliches (1979) provides the starting point for our analysis. It specifies a Cobb-Douglas production function for the output of new, economically useful knowledge depending on R&D input. The most common approach to measure the production of new knowledge is patenting activity (see e.g. Jaffe 1986). Referring to our theoretical considerations, we apply this basic knowledge production function on regional level and extend it by adding age-specific compounds of human capital while simultaneously accounting for a potential independent age effect by including the age structure of the labour force.

Our extended knowledge production function then yields

$$P_i = \alpha \prod_{a=1}^{m} S_{ai}^{\gamma_a} \; H_{ai}^{\beta_a} \quad , \quad \text{a=1,…, m ; i=1,…, n} \qquad (1)$$

with P_i being the number of patents in district *i* and vectors H_{ai} incorporating the stock of different sources of human capital in the corresponding district, separately for *m* different age groups *a*. S_{ai} includes the shares of these age groups in district *i*'s

total labour force, representing the independent age effect. Vectors β_a and γ_a denote age-specific (!) production elasticities for the input factors. That is, the percentage change in patenting activity resulting from a one percentage change in the input factor considered. Term *a* is a constant, capturing, as in any production function, the overall efficiency of the invention process.

Data and variables used For P_p we use the number of business patents per district in 2000 provided by the German Patent Office (Greif 2002). The independent age effect would be approximated by the workers' age structure on district level, namely age shares for the age groups <35 years, 35 to 49 years and 50+ years in the district's total employed labour force. Human capital in its broad definition cannot be measured directly. Empirical studies usually proxy acquired formal knowledge by the level of schooling or educational attainment and experience is most often measured by general work experience or, for the firm-specific part, organisational tenure. However, as we assume in our theoretical framework (see Section 2), the stock of human capital is age-specific. Given this, using variables aggregated across different ages does not suffice. We therefore propose to include formal education as well as firm- and industry-specific work experience for older and younger workers separately. The stock of age-specific human capital available in a region then consists of aggregate knowledge and experience variables. We draw this information from the workers' professional careers provided in the Employment Sample of the German Federal Employment Office (Regional File). This data set contains complete work histories for 2% of all workers subject to social insurance contribution in Germany between 1975 and 2001. Specifically, we suggest to alternatively include the share of academic workers (general formal knowledge) or the share of engineers and technicians (technological knowledge) as well as, again alternatively, mean firm- or industry-specific experience per district[3]. All these variables are calculated separately for the three age groups specified. Control variables are the number of workers in 1997 to account for the size of the local labour market, an east-west dummy as well as a categorical variable for the degree of urbanisation, controls for the sectoral composition of the districts' labour force and finally the number of academic patents per district to account for spillovers from academic research. All explanatory and control variables are lagged by three years assuming that it takes a certain time from the first idea over implementation up to successful patenting application.

Estimation and Results Dealing with nonnegative and discrete patent counts, we are able to obtain unbiased and efficient estimates for the parameters of interest, β_a and

3 Due to the shorter data availability for East Germany the computation of the experience variables takes only into account the years 1991 – 2001.

γ_a by applying a negative binomial regression model allowing for overdispersion (for details see Cameron et al. 1986). Simultaneously encompassing all three age groups as well as the respective age-specific human capital indicators leads to multicollinearity bias. We therefore focus on the oldest and the youngest age group (a = 1 for <35 years, a=3 for 50+ years). Similarly, as we can only include one type of knowledge (academic or technological) and one type of experience (sector-specific or firm-specific) at a time, we estimate four different models A to D. Table 1 provides the parameter estimates for the independent age effect and the age-specific knowledge variables for age groups <35 and 50+ years on business patenting activity in 2001 obtained by applying standard maximum likelihood procedures[4]:

Table 1: Estimates for independent age effect and age-specific knowledge variables.

	Model A	Model B	Model C	Model D
Intercept	-2.2	-2.2	-1.9	-1.6
Independent age effect				
share of workers <35 years	3.0 *	3.0 **	3.1 **	3.3 **
share of workers 50+ years	5.7 ***	5.6 **	5.8 ***	5.6 ***
Age specific human capital				
a) Knowledge:	*academic*	*academic*	*engineering*	*engineering*
share of workers with knowledge, <35	2.7 **	2.8 **	5.0 **	5.0 **
share of workers with knowledge, 50+	2.8 **	2.9 **	0.1	0.5
b) Experience:	*firm-spec.*	*sec.-spec*	*firm-spec.*	*sec.-spec*
share of workers with experience, <35	0.0011	-0.0011	-0.0016 **	-0.0015 **
share of workers with experience, 50+	0.0015 *	0.0015 *	0.0021 **	0.0019 **

significance levels: * 10%, ** 5%, *** 1%.

Age and patenting activity are positively and significantly related on district level. Including age shares of the youngest and oldest age group, we identify a positive influence of both, the share of younger and older workers, with higher and more significant effects for older workers. This double-positive impact of older and younger workers is particularly interesting as we could think of spillover effects

4 We thereby control for labour market size (workers per district), east-west-dummy, degree of urbanisation, academic patenting activity and sectoral composition.

between age groups: if there is enough up-to-date formal knowledge in the youngest age group, a high share of experienced older labour might enhance patenting activity, leading to a positive net age effect, even if our theoretical framework rather would have supported a decreasing relationship between age and inventive performance due to decreasing exploitation abilities and motivation (see Section 2.2).

Our main result is that both the stock of general academic and technological knowledge matter for patenting activity. However, whereas the availability of general academic knowledge shows a positive influence of equal strength for older and younger workers ($2.8 \leq \beta_a \leq 3.0$, a=1;3) which is significant on 5%-level, this is not the case for technological knowledge: We find significant positive effects for the share of younger engineers. With parameter estimates for β_1 between 5.6 and 5.8 on a 1%-significance level, the stock of young technological knowledge does also seem to be far more relevant for a districts' patenting performance than general academic knowledge. Engineering knowledge of age group 50+ is, to the contrary, not significant and the parameter estimate close to zero. This suggests a decreasing relevance of 'older' technology-related human capital for innovative output on district level, which is in line with the theoretical framework we established in Section 2.1: Human capital close to the technological frontier, such as engineering knowledge, particularly matters for patenting activity. However, as these areas also are characterised by a high rate of technological change, the effect for older and therefore partly outdated knowledge is insignificant. This also explains why academic knowledge, representing more general human capital seems to be less or not at all affected by depreciation effects.

Both the districts' mean stock of firm- and sector-specific experience have a small but positive influence on patenting output for the older age group (significance level 5% and 10%). The sign for the effect of experience in the younger age group is, however, surprising: The higher the stock of experience, the lower is patenting performance. A possible explanation is the so-called 'Silicon Valley effect' (Fallick et al. 2005), claiming that high performers display high job mobility, within as well as across industrial sectors. In this context, lower flows of labour between sectors and/or companies as indicated by longer tenure could lead to lower patenting performance, because the less innovative workers stay in their jobs whereas the more innovative ones leave.

4. Conclusion

The main findings of our analysis of the age-dependency of patenting activity on German district level indicate that the stock of young engineering knowledge significantly enhances patenting performance, whereas we do not find any effect for the age group 50+. On aggregate level, we find a positive independent age effect for

both the younger and the older age group and suggest to attribute this double-positive impact of older and younger workers to spillover effects between age groups.

The potential contributions of these results to future research are as follows. First, current economic wisdom concerning age-specific human capital will not suffice to shape efficient human resource strategies and labour market policies in the future. Age-specific particularities in work motivation and age-related abilities independent of human capital will have to be equally considered. Second, combining conceptualisations put forward by economics and I-O psychology in a formal model and to implement it econometrically leads to a fruitful exchange between the disciplines. We expect that in the future large-scale employment data sets provide promising opportunities for indirectly testing psychological phenomena as in our case.

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This study uses the factually anonymous IAB Employment Samples IABS (Regional File 1975-2001). Data access was provided via a Scientific Use File supplied by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB). For data documentation see Hamann et al. (2004).

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IV. Demographic Aspects of Human Capital Accumulation

Knowledge Transfer within Teams and Demographic Change

Michael Kuhn, Pascal Hetze

1. Introduction

In the presence of population ageing there are strong concerns about (re-)integrating older workers into the labour market. While these concerns frequently relate to the sustainability of social security and the assurance of a sufficient labour supply within a shrinking workforce, another argument raised in the debate is that insufficient use is being made of the experience and know-how older workers can contribute to the running of firms and organisations. This section explores the latter argument by analysing the formation of young and old (possibly experienced) workers to teams and the incentives that govern the transfer of knowledge from experienced old workers to young workers within these teams.[1]

It is not always clear in the political debate as to what sort of know-how is being referred to and why older workers should have a particular advantage in providing it (as opposed to general education or learning-by-doing). Generally, one may think of problem-solving skills or social competencies. We believe that the handing-down of expertise and know-how plays a particularly important role in the context of professional partnerships including the free professions (e.g., physicians, lawyers, business consultants, brokers, etc.), craftsmen's workshops and scientific teams. Within these partnerships know-how and skills can frequently only be acquired through the collaboration with experienced partners and/or under their supervision (see e.g., Morrison et al. 2004).[2]

For instance, medical know-how includes certain diagnostic or surgical skills related to rare conditions and/or complications. Almost by definition, the knowledge how to diagnose such conditions and/or how to deal with complications cannot be easily taught as part of the formal medical education but requires the sus-

1 A survey (in German language) of key issues relating to the training of older workers is contained in Hetze et al. (2007). Recent empirical evidence with respect to continued education in Germany is provided by Ripahn et al. (2006, 2007).

2 Such knowledge, which is difficult to codify, is referred to as 'implicit' or 'tacit knowledge' (Polanyi, 1966).

tained collaboration between a junior and a senior partner.[3] Other examples relate to lawyers, where junior partners benefit from their senior collaborator's know-how of building a good case, of cross-examining witnesses and of making stick a final speech. In consultancy, senior partners may pass on important know-how about the acquisition of new clients or about how to competently deal with demanding clients. In science, junior researchers benefit from the experimental and paper writing skills of their senior counterparts. Thus, while we cast our analysis in the more general terms of 'training' and 'teams' and while we believe that our insights are of a general nature, our model lends itself most naturally to an economy composed of professional partnerships, in which trade-specific know-how is passed on by way of extensive interaction between a junior and a senior partner.[4]

Generally, one may presume that in the course of population ageing, the age structure of the workforce within a profession will shift towards older age groups in a similar way as the age structure of the working population in general.[5] This is the backdrop against which this paper seeks to provide answers to the following set of questions: (i) do the processes of team formation and knowledge transfer lead to efficient outcomes, and (ii) what is the effect of workforce ageing on the transmission of knowledge?

We consider an over-lapping generations (OLG) framework, where agents from different (or possibly the same) age groups form professional partnerships/teams in order to produce some output. Whenever there is a match between young workers and experienced old workers there is also scope for the provision of training, albeit at a cost. We establish the age composition of partnerships and the supply of training that maximise the profession's long-run net surplus (taken across all teams and all generations) and show how they depend on the production and training technology, the discount rate and the age structure of the profession (workforce).

We compare the profession's optimum with the allocation within a decentralised economy, where experienced old agents have to be given incentives to form teams with young partners and train them. Training is undertaken, if and only if the young pay appropriate compensation to the old agents. Specifically this requires that

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3 Of course, one could argue that to some extent this know-how can be acquired through learning-by-doing. However, the example drawn from medicine makes it very clear that the costs of learning-by-doing may be very high to the patient and the physician.

4 A similar situation arises in owner-run enterprises with regard to the transfer of company specific knowledge from the current owner to her successor. This frequently leads to an arrangement, where for a certain span of time the current and future owner work as a team before the enterprise is transferred.

5 See e.g., OECD (1998) and Börsch-Supan (2003) on (general) labour force ageing in OECD countries and Germany, respectively. Kopetsch (2004) provides data on the drastic ageing process amongst German physicians.

a young worker's maximum willingness to pay for training exceeds the minimum price charged by old workers. We show that the willingness to pay increases in the expectation of young workers to be able themselves to sell training in their second period of life. This expectation depends on the demography of the workforce.

For a shrinking workforce there is a period-by-period over-supply of old workers leading to a potential over-supply of training. This may suggest that there should be sufficient scope for the transfer of knowledge, but such an intuition is misleading. Indeed, the converse is true. When there is an excess supply of (skilled) old workers not everyone can expect to find a trainee. While young workers benefit from this when purchasing training, they will anticipate that within an ageing workforce they will belong to the 'long-side' of the market once they have acquired skills. The expected future returns to training are adjusted downwards and, accordingly, the willingness to pay for training at present. Hence, the scope for training is curtailed within a shrinking work force.

The extent to which ageing reduces the incidence of training and the welfare consequences depend crucially on (i) the skill/age structure of teams and (ii) the mechanism by which the training fee is determined. Under assortative matching, workers segregate into skill-specific teams unless it is for the explicit purpose of training. In this case a negative impact of ageing on the incentives to engage in training can only be expected if and only if old workers make a profit from selling on their training to younger workers, where the expectation of this profit depends on the probability of finding a trainee. In contrast, if the competition for trainees within an ageing workforce erodes the training fee to the level of a skilled worker's opportunity cost, then the expected profit is zero regardless of the age structure. We show that the 'competitive' degree of training corresponds to the profession's optimum.

The effect of ageing turns out to be more complex if it is optimal to form mixed teams with skilled and unskilled partners even in the absence of training. In this case, two 'markets' interact, one for a place in a mixed team without training and one for training. Even if the competition for trainees erodes the training fee to the level of opportunity cost, returns to training may still arise from acquiring a skill premium within a mixed team. As the probability of entering a mixed team increases in the share of young workers, ageing continues to depress the expected returns to training. In such a situation over- or under-provision of training may arise relative to the profession's optimum unless there is competition in the market for mixed teams (without training) as well.

The issues of team formation and compensation within teams that are central to our model also feature in Legros et al. (2003), who focus on the role of nontransferability of wealth between team mates. This work is applied by Gall et al. (2006) to the timing of education (i.e., investments in productivity). While these issues bear some similarity to our work, this work differs in substance. In Gall et al. (2006)

education is attained outside the team and their timing relates to whether education is acquired before or after matching has occurred. This is obviously different from our context where by definition training can only occur within a team. Furthermore, the model by Gall et al. (2006) is essentially static, in particular there is no OLG structure and the role of ageing is not addressed.[6] Closer in spirit to our work is Tykvova (2007), who studies the incentives for experienced partners to take on board and, implicitly, train junior partners. In her model, the team is a syndicate in the private equity and venture capital market. Young investors can benefit from the expertise of their established counterparts both by working in a more productive team and by being able to learn from them. In contrast to the static (one period) case, where experienced partners have no incentive to involve junior partners, heterogeneous syndicates with skilled and unskilled investors can be found in the dynamic (two period) setting. Inexperienced investors initially accept comparably worse conditions with respect to their payoff. Nonetheless, her model deviates substantially in that she, too, does not consider the dynamic incentives within an OLG economy consisting of many periods. Furthermore, she does not study the socially optimal allocation and therefore cannot address the efficiency of training.

Morrison et al. (2004) consider the incentives to pass on non-contractible knowledge within partnerships. Thus, they have in mind a similar set-up as we do. However, in their analysis they focus on the question how the structure of partnerships overcomes the moral hazard problem with regard to the provision of training. The argument is that only agents who have actually received training are willing to invest into the commonly illiquid shares of a partnership. If the partnership were taken over by untrained agents, it would lose reputation thus eroding the returns on the shares. In such a case senior partners have an incentive to provide effective training so as to ensure that they are able to profitably sell on their own illiquid shares. Morrison et al. (2004) consider a single infinitely living firm and a stable population. Thus, they cannot address the role of age structure and population shrinking. Furthermore, they do not consider the efficiency of training allocations. By identifying the mechanism by which training becomes enforceable within partnerships, however, Morrison et al. (2004) provide an important basis for our model, where we assume for simplicity the contractibility of training.[7]

The remainder of the article is structured as follows. The next section presents the model. Section 3 examines which team structure and which rate of training

6 Besley et al. (2006) study the effect of incentive contracts for teachers when teachers and students are matched to form 'educational teams'. Here, too, age structure plays no role.

7 In considering the role of demographic developments for the evolution of a profession over time our model also bears some resemblance to the literature on the demography of organisations (e.g. Keyfitz 1973, Vaupel 1981, Feichtinger et al. 2007). This literature is mostly concerned with the scope for promotion, but does not consider the feedback on incentives such as those for training activities.

maximise the profession's net surplus over time. Section 4 studies the matching and training allocation in a decentralised economy and examines the impact of ageing. Section 5 concludes. The present article is to be understood as a summary of the more extensive analysis in Kuhn et al. (2007). In order to keep the presentation as brief and accessible as possible, we focus in most places on an intuitive argument. Readers who are interested in the formal aspects of the analysis are referred to Kuhn et al. (2007).

2. The Model

We consider a profession (e.g., of physicians, lawyers or artisans) consisting of overlapping generations, where agents produce (and live) for two periods. Furthermore, agents may receive training in the first period of their career. Thus, there are three types of agents who may form partnerships in any given period: young agents (*y*), old agents with skills (*os*), and old agents without skills (*ou*). An agent can acquire skills only through receiving training while young. At the same time training can be provided only by old agents with skills. A partnership consists of two agents jointly producing output. Each partner can either have low (*l*) or high (*h*) productivity. Only skilled old agents, *os*, can be of type *h*, while the young, *y*, and unskilled old agents, *ou*, are of type *l*. Partnerships composed of different types of agents can thus produce the following output levels

$$\begin{aligned}\theta_{l,l} &:= \theta(y,y) = \theta(y,ou) = \theta(ou,ou)\\ \theta_{l,h} &:= \theta(y,os) = \theta(ou,os)\\ \theta_{h,h} &:= \theta(os,os)\end{aligned}.$$

We assume the natural ranking $0 \le \theta_{l,l} \le \theta_{l,h} \le \theta_{h,h}$. Furthermore, let us define

$$\chi := \theta_{h,h} + \theta_{l,l} - 2\theta_{l,h}$$

as the net surplus of skill segregation. In analogy to the condition for assortative matching (Becker 1973), it is then true that segregated teams are privately and socially preferable to teams composed of skilled and unskilled workers (mixed teams) if and only if $\chi > 0$. This is the case if and only if the combined output of two segre-

gated teams composed, respectively, of high and low productivity workers only exceeds the output of a couple of mixed teams.[8]

Training will only take place between skilled old agents and young agents, thus only within (y,os) matches. Let δ denote the total costs of training a particular young worker. Young workers are heterogeneous with respect to their 'trainability', the latter reflecting their ability and motivation. Without loss of generality, we assume that δ is uniformly distributed on [0,1], where the most motivated/able can be trained at zero cost. The output in a team in which training takes place can thus be written as $\theta_{l,h}$-δ.

The total population of workers at time t is given by $N(t)=\sigma_o(t)+\sigma_y(t)$, where $\sigma_y(t)$ and $\sigma_o(t)=\sigma_{os}(t)+\sigma_{ou}(t)$ denote the numbers of young and old workers, respectively. The population evolves as follows

$$\sigma_o(t)=\sigma_y(t-1) \qquad (1a),$$

$$\sigma_y(t)=(1+n)\sigma_y(t-1) \qquad (1b).$$

Thus, all young workers survive into their second period and reproduce at a rate $1+n$, where n gives the net growth rate of the population. Dividing (1b) through (1a) gives

$$\frac{\sigma_y(t)}{\sigma_o(t)}=1+n=:\lambda$$

as a measure of the age structure. Note that $\lambda<1$ in a shrinking population, $\lambda=1$ in a stable population and $\lambda>1$ in a growing population. Using $\sigma_y(t)=\lambda\sigma_o(t)$ we can write $N(t)=(1+\lambda)\sigma_o(t)=[(1+\lambda)/\lambda]\sigma_y(t)$. Furthermore, it is easily verified that $N(t)=\lambda^t N(0)$ and

$$\sigma_y(t)=\frac{\lambda^{t+1}}{1+\lambda}N(0),$$

$$\sigma_o(t)=\frac{\lambda^t}{1+\lambda}N(0)$$

8 A number of recent empirical studies assess empirically the effect of age composition on the productivity of teams, providing mixed results. Using data from manufacturing, Börsch-Supan et al. (2007) and Weiss (2008) find that age heterogeneity is detrimental. Veen et al. (2008) find that the role of age heterogeneity depends on the type of activity. It lowers (raises) productivity in areas in which work is mostly of a routine (creative & innovative) nature.

where $N(0)$ is the size of the initial population. Define $T(t) \in [0,1]$ as the share of young workers who receive training in period t. We then find $T(t)\sigma_y(t)$ as the incidence of training in period t so that

$$\begin{aligned}
\sigma_{os}(t) &= T(t-1)\sigma_y(t-1) = T(t-1)\sigma_o(t) \\
\sigma_{on}(t) &= [1-T(t-1)]\sigma_o(t) \\
\sigma_{os}(t)/\sigma_o(t) &= T(t-1)
\end{aligned} \quad .$$

It follows that for a steady state with $T(t\text{-}1)=T(t)=T$ the share of skilled workers in the population is constant with $\sigma_{os}(t)/\sigma_o(t)=T$. Furthermore, minimising the cost of training a number of $T(t)\sigma_y(t)$ workers implies that those young workers and only those should be trained for whom $\delta \leq T(t)$. Hence, we can write aggregate training costs as

$$\int_0^{T(t)} \delta d\delta = \frac{T(t)^2}{2}$$

and marginal training costs as $T(t)$.

3. Optimal Training from the Profession's Perspective

In this section we consider the allocation of workers to teams and the rate of training that constitutes a long-run optimum from the perspective of the whole profession. An optimal allocation maximises the present value of the flow of net surplus from production within the profession, i.e., the (discounted) outputs $\theta_{i,j}$ with $i,j \in \{h,l\}$, aggregated over all teams of type i,j and over all time periods $t \in [0,\infty]$.[9] Assuming that no other inputs apart from labour are used in production and assuming that output can be transferred freely between the agents, the maximisation of net surplus over time corresponds to the maximisation of the flow of consumption and/or utility of the members to the profession. For ease of reference, we call this allocation the 'profession's optimum' and use it as a benchmark for assessing potential inefficiencies within a decentralised economy.

In the following we focus on a weakly shrinking population. Thus, we consider $\lambda \in [0,1]$. For the initial state in period $t=0$, we assume without loss of generality

9 Assuming an infinite time horizon does not substantially reduce the generality of our analysis. See Kuhn et al. (2007).

$N(0)\equiv 1$, $\sigma_y(0)=\lambda/(1+\lambda)$ and $\sigma_o(0)=1/(1+\lambda)$. Furthermore, we assume that $\sigma_{os}(0)=\sigma_o(0)$, i.e., that all old workers are skilled initially.[10]
It is immediately clear that in the absence of training workers should be matched to teams according to the rule of assortative matching. Thus, segregated teams are preferred if and only if $\chi=\theta_{h,h}+\theta_{l,l}-2\theta_{l,h}>0$. In the following we consider this case first.

Optimal Training with Assortative Matching ($\chi>0$)
Denoting $\varrho:=1/(1+r)$ as the discount factor corresponding to an interest rate r, one can show that the following rate of training maximises the present value of the flow of net production[11]

$$T^S = \varrho\frac{\theta_{h,h}-\theta_{l,l}}{2}-\frac{\chi}{2} \qquad (2).$$

The efficient rate of training increases with the discounted return $\varrho(\theta_{h,h}-\theta_{l,l})/2$ (per worker) from having a purely high skilled team instead of a purely low skilled team and decreases with the opportunity cost of training, amounting to the loss of output $\chi/2$ (per worker) when production takes place in mixed teams instead of the more productive segregated teams. Naturally, the optimal rate of training falls with the interest rate, but interestingly, it does not depend on the age structure of the population.

Optimal Training with Mixed Teams ($\chi<0$)
When $\chi=\theta_{h,h}+\theta_{l,l}-2\theta_{l,h}<0$ it is optimal to form mixed teams even when training does not take place. As a preliminary, recall that for a steady-state value, T, we have in each period $t\in[0,\infty]$ a number of $\sigma_{os}(t)=T\sigma_o(t)$ skilled agents facing $\sigma_{ou}(t)+\sigma_y(t)=(1-T+\lambda)\sigma_o(t)$ unskilled agents. As it is readily checked, we then have

$$\sigma_{os}(t)\geq\sigma_{ou}(t)+\sigma_y(t)\Leftrightarrow T\geq(1+\lambda)/2 \qquad (3).$$

For $T<(1+\lambda)/2$ the number of unskilled agents (young or old) in each period exceeds the number of skilled agents. Thus, there is an insufficient number of skilled workers to form mixed teams and a number of unskilled-only teams are formed. In

10 For $\sigma_{os}(0)<\sigma_o(0)$, a potential lack of skilled workers may lead to the incidence of training being bounded from above for an initial number of periods. For $\lambda<1$ the shrinking population will imply eventually that the supply of training outstrips the demand and the optimal rate of training will be realised as an interior solution.

11 Here, $\varrho\in[z/(\theta_{h,h}-\theta_{l,l}),(\chi+1)/(\theta_{h,h}-\theta_{l,l})]$ guarantees an interior solution $T^S\in[0,1]$.

contrast, for $T>(1+\lambda)/2$ a surplus of skilled old workers is grouped into skilled-only teams within each period. For $T=(1+\lambda)/2$ (and for this value only) all agents are grouped into mixed teams (with or without training).

As it turns out, the flow of net production and consequently the optimal rate of training depend on whether there is an excess or shortfall of skilled agents. The following rates of training can be shown to maximise the flow of net surplus for the whole profession[12]

$$T^S = \begin{cases} \varrho\left(\theta_{l,b} - \theta_{l,l}\right) \Leftrightarrow \varrho \leq \dfrac{1+\lambda}{2\left(\theta_{l,b} - \theta_{l,l}\right)} \\ \dfrac{1+\lambda}{2} \Leftrightarrow \varrho \in \left[\dfrac{1+\lambda}{2\left(\theta_{l,b} - \theta_{l,l}\right)}; \dfrac{1+\lambda}{2\left(\theta_{b,b} - \theta_{l,b}\right)}\right] \\ \varrho\left(\theta_{b,b} - \theta_{l,b}\right) \Leftrightarrow \varrho \geq \dfrac{1+\lambda}{2\left(\theta_{b,b} - \theta_{l,b}\right)} \end{cases} \quad (4).$$

The structure we find for the optimal rate of training is intuitive. If and only if the discount factor is sufficiently low (implying a high interest rate r), it is socially optimal to train only a small share of young agents $T^S \leq (1+\lambda)/2$ and rather save the high upfront training costs (first row in (4)). This is the case even if it leads to an excess supply of untrained agents. For high values of the discount factor, it is optimal to train at the rate $T^S \geq (1+\lambda)/2$ in order to realise future productivity gains amounting to $\varrho(\theta_{b,b}-\theta_{l,b})$ even if this implies an excess supply of skilled agents (third row in (4)). Finally, for intermediate values of the discount factor, it is optimal to train at the rate $(1+\lambda)/2$ so that in any period the number of skilled agents just balances the number of unskilled agents. In this last case only does the rate of training depend on the age structure. As expected, the rate of training then increases with the rate of reproduction, λ. This is because a greater number of future young/unskilled agents would have to be matched with skilled agents. In this intermediate case, the rate of training is thus independent of the discount factor. In contrast, the rate of training increases with the discount factor both at the upper and lower end.

4. The Decentral Allocation

We now turn to the allocation of training when the agents organise themselves into partnerships and decide decentrally on whether or not to engage in training activities. In order to focus on the incidence of training, we assume that the matching

12 Assuming $\varrho \leq (\theta_{b,b}-\theta_{l,b})$ guarantees $T^S \leq 1$ as an interior equilibrium.

process is frictionless. Once a team has formed and production takes place the output is shared between the partners. In homogeneous teams (composed of either skilled or unskilled agents only) output is split equally. For mixed teams composed of a skilled and an unskilled worker, a sharing rule determines a net transfer to the skilled agents as an incentive to take on board unskilled partners and, possibly, to provide training. We continue to assume a weakly shrinking population, i.e., $\lambda \leq 1$. Note that this implies that a skilled old agent cannot expect with certainty to be matched with a young agent. Similar to the case of the social optimum we determine the steady-state rate of training as the share of young workers receiving training within each period.

As a preliminary, we need to determine whether or not mixed teams would form in the absence of training. Recall that for $\chi=\theta_{b,b}+\theta_{l,l}-2\theta_{l,b}>0$ two segregated teams dominate two mixed teams in terms of total output. It is then readily shown in analogy to Becker (1973) that mixed teams will never be formed in a decentral economy unless for the purpose of training. Intuitively, this is the case because for $\chi>0$ the compensation a skilled agent asks for when entering a mixed team instead of teaming up with a skilled partner always exceeds an unskilled agent's willingness to pay for entering a mixed team. In contrast, for $\chi<0$ the minimal transfer that is necessary to lure a skilled agent into a mixed team exceeds the unskilled agent's willingness to pay. In the absence of other constraints, mixed teams would therefore form. This implies that similar to Becker (1973) efficient matching is always attained within a decentralised economy. We can now turn to the provision of training.

4.1. Decentral Training with Assortative Matching ($\chi>0$)

By the previous argument, mixed teams are not formed unless it is for the purpose of training. In the following, we denote with b the net transfer from young to old workers in teams where training takes place.[13] Skilled agents prefer training a younger colleague at cost δ over forming a segregated (os,os)-team if and only if $(\theta_{l,b}-\delta)/2+b \geq \theta_{b,b}/2$ or

$$\pi_o(\delta,b) := \frac{\theta_{l,b}-\theta_{b,b}}{2} - \frac{\delta}{2} + b \geq 0 \qquad (5).$$

The discounted, expected net surplus (over two periods) of a young worker who engages in training can be written as

13 Along the lines of Morrison et al. (2004) such a transfer may be implicit in the value of the shares sold on by a senior partner to a (junior) associate.

$$\pi_y(\delta, b, \delta^e, b^e, p) := \frac{\theta_{l,b} - \theta_{l,l}}{2} - \frac{\delta}{2} - b + \varrho\left[\frac{\theta_{b,b} - \theta_{l,l}}{2} + p\pi_o(\delta^e, b^e)\right] \qquad (6).$$

Here, $p \in [0,1]$ is the conditional probability of a trained worker to enter a mixed team and train in the second period, $\pi_o(\delta^e, b^e)$ is the expected profit from training a future worker, where δ^e is the expected training cost and $b^e = b(\delta^e)$ the corresponding transfer. The net surplus $(\theta_{l,b} - \theta_{l,l} - \delta)/2) - b$ during the training period is thus amended by the present value of the net surplus expected as an old worker $\varrho[(\theta_{b,b} - \theta_{l,l})/2 + p\pi_o(\delta^e, b(\delta^e))]$. The expected surplus from training is composed of surplus from being able to work in a skilled team (the first term in the square brackets) and the expected profit from selling training (the second term). As the supply condition (5) has to hold, it follows that the expected future surplus increases (weakly) in the probability of being matched with a future young worker, p.

Assuming that any restrictions on the transfer b, such as uniformity constraints or limited liability constraints, apply equally to all types δ, then there are no gaps in training in the sense that for a given rate of training, T, all workers with $\delta \in [0,T]$, and only those, will train. We can thus determine T and T^e, respectively, as the current and expected rate of training. Assuming, without much loss of generality, that $T^e \leq T$ we can write $p = (T^e \sigma_y)/(T\sigma_o) = T^e \lambda / T \leq 1$, as determined by the current and expected rate of training as well as by the age structure λ. We can now proceed to determine the steady-state allocation of training.

4.1.1. Steady-state Training Intensity and Incidence of Training

Substituting from (5) into (6) and observing (2) we can write

$$\pi_y(\cdot) = T^S - \delta - \pi_o(\delta, b) + \varrho\, p\pi_o\left[\delta^e, b(\delta^e)\right].$$

Training is demanded by young agents as long as $\pi_y(.) \geq 0$ or, equivalently, as long as

$$\delta \leq T^S - \pi_o(\delta, b) + \varrho\, p\pi_o\left[\delta^e, b(\delta^e)\right] =: T^D \qquad (7).$$

Here, T^D denotes the marginal training cost as well as the equilibrium rate of training in a steady-state. The expression allows us to interpret the incentives that govern the demand for training. The social (i.e., the profession's) value of training, T^S, forms one part of the private incentive. However, the full private return to training contains additional rent-shifting elements which do not contribute to the social value: On the one hand, the private return (to a young agent) is reduced to the ex-

tent that an amount $\pi_o(\delta,b)\geq 0$ of the return to training falls to the old agent (as trainer). On the other hand, the private return is increased to the extent that training can be sold at a profit to the next generation of young workers. Note that the discounted value of the expected return $\varrho p\pi_o(\delta^e,b(\delta^e))$ increases in the probability p that a trainee can be found. Which of these rent-shifting elements, if any, dominates the total incentive depends on the pricing process and the expectations about the future as determined, inter alia, by the age structure of the workforce.

Consider now a steady-state, where $\delta^e=T^e/2$ for a uniform distribution and where[14]

$$T^e = T^D = T^S - \pi_o\left[T^D, b\left(T^D\right)\right] + \varrho\lambda\pi_o\left[T^D/2, b\left(T^D/2\right)\right].$$

The rate of training that is efficient from the profession's point of view is then realised only if $\pi_o(T^D,b)=\varrho\lambda\pi_o(T^D/2,b(T^D/2))$. This is the case either (i) if the current profit from training the marginal worker cancels out the expected profit from training, an unlikely event, or (ii) if both the current profit from training the marginal worker and the expected profit from training are zero.

Define $\Theta:=T^D\sigma_y/(\sigma_y+\sigma_o)=T^D\lambda/(1+\lambda)$ as the per-capita incidence of training in a steady- state, i.e., as the long-run share of the total population that receives training. The effect of age structure on the per-capita incidence of training is then given by

$$\frac{d\Theta}{d\lambda} = \frac{T^D}{(1+\lambda)^2} + \frac{\lambda}{1+\lambda}\frac{dT^D}{d\lambda},$$

where $dT^D/d\lambda>0$ can be shown formally (see Kuhn et al. 2007) but also follows intuition. The impact of population ageing (as measured by a decrease in λ below 1) on the incidence of training can thus be decomposed into two distinct effects: one demographic, one economic. Both effects are negative. The incidence of training is reduced due to a lower pool of potential trainees, i.e., the young, (the demographic effect) and by a reduction in the steady-state rate of training (the economic effect, reflecting the reduced return to training). We can thus make a first summary.

Proposition 1 (i) The steady-state rate of training implemented in a decentral economy is below (above) the profession's optimum if and only if the old agents attain a profit on the marginal trainee that exceeds (falls short of) the expected profit from selling training to future generations. (ii) The negative demographic impact of population ageing (i.e., a lower λ) on the per-capita incidence of training in a steady- state

14 Obviously, equation (7) defines T_D only implicitly.

is compounded by an economic effect driven by the negative impact of ageing on training incentives.

4.1.2. Training in the Presence of Price Competition

So far we have not made any assumptions about the mechanism by which the training fee b is determined. Naturally, one would expect the details of this mechanism to have a bearing on the rate of training. This is because it determines the current and future distribution of rents and thus the incentives to train. As one special case, consider a set-up where the training fee is determined together with the matches in a process of price competition. Suppose that the training cost δ is perfectly observable and contractible and that young and old partners compete à la Bertrand seeking to attract favourable partners. For a shrinking population there is always an excess supply of skilled agents. But then, Bertrand competition for trainees implies that $\pi_o(\delta,b)= 0$. The skilled agent's surplus from training is fully extracted. Naturally, this holds for the future as well so that $\pi_o(\delta^e,b^e)=0$. From (7), it then follows immediately that $T^D=T^S$.

Proposition 2 (i) In the case of price competition, the optimal rate of training is attained in a decentral setting. (ii) Age structure has no effect on the rate of training T^D.

Note that ex-post price competition for trainees implies partnership-specific fees. These are bargained down to the minimum at which a skilled worker is willing to supply training. The permanent excess supply of training in a steady-state with a shrinking population gives rise to the rational expectation that the surplus of skilled workers will be fully extracted in future periods, too. But then, the private return to becoming trained is independent of whether or not one is able to train in the future and is thus independent of the age structure. Indeed, the private return to training equals the (shared) excess surplus generated by a highly skilled team as compared to an unskilled team, which corresponds to the return to the profession.

4.2 Decentral Training with Mixed Teams ($\chi<0$)

We now turn to the setting, where for $\chi<0$ it is optimal from the perspective of the profession to form two mixed teams rather than two segregated teams. In the following, we assume as a benchmark that the partners split the net output of the team and define a as the net transfer from the unskilled to the skilled partner. Furthermore, define

$$\underline{a} := \frac{\theta_{h,h} - \theta_{l,h}}{2}; \qquad \bar{a} := \frac{\theta_{l,h} - \theta_{l,l}}{2}$$

as the net surplus of a skilled and unskilled worker, respectively, from entering a mixed team. Hence, a mixed team forms in the absence of training if and only if the transfer a is chosen from the interval $[\underline{a},\bar{a}]$. Otherwise it would be optimal either for the skilled or for the unskilled partner to leave the mixed team and rather form a segregated team with an outside agent of the same type. If, however, $a \in [\underline{a},\bar{a}]$ both the skilled and unskilled partners of a mixed team benefit from the arrangement. It is easy to check that $\underline{a}<\bar{a}$ if and only if $\zeta<0$, so that we may assume that mixed teams will always be formed for $\zeta<0$ (but only then). Recalling (3), it must then be true that apart from mixed teams a decentral economy features (i) no segregated teams if $T=(1+\lambda)/2$, (ii) only segregated teams with unskilled workers if $T<(1+\lambda)/2$ and (iii) only segregated teams with skilled workers if $T>(1+\lambda)/2$.

We can now turn to the provision of training. Consider a mixed team consisting of a skilled agent and a young agent. Skilled agents prefer to train their younger colleagues at cost δ if and only if $(\theta_{l,b}-\delta)/2+b \geq \theta_{l,b}/2+a$ or, equivalently,

$$b \geq \delta/2 + a = \underline{b}(\delta, a) \qquad (8).$$

The distinguishing feature of the setting in which mixed teams form is that there are now two 'markets': one for the formation of mixed partnerships (without training) and one for training. The relationship in (8) establishes an arbitrage condition between the two markets from the perspective of the old agent.

Consider now the young partner who is matched with a skilled agent. When undergoing training (rather than just working as an untrained junior partner) the young worker expects a discounted net surplus (over two periods) amounting to

$$\pi_y(\delta, b, a, \delta^e, b^e, a^e) = -\frac{\delta}{2} - b + a + \varrho \left\langle \begin{array}{l} \left(\theta_{h,h} - \theta_{l,l}\right)/2 + \left(p_T + p_M\right)\left(a^e - \underline{a}\right) \\ + p_T\left[b^e - \underline{b}\left(\delta^e, a^e\right)\right] - p_{NT}\left(\bar{a} - a^e\right) \end{array} \right\rangle \quad (9),$$

where (δ^e,b^e,a^e) refer to the expected values in the future period and where p_T and p_M denote the conditional probabilities that a skilled worker enters a mixed team with training and a mixed team without training, respectively. Similarly, p_{NT} is the conditional probability that an unskilled worker is offered a place in a mixed team (without training). The net surplus of training can be understood as follows. In the first period, the young agent receives a negative surplus from training (as opposed to working in a mixed team without training) equal to $-(\delta/2)-b+a$, where $b-a$ is the 'surcharge' for training. The net return to training is composed of four parts: First, a

trained agent is able to obtain at least the extra return from working in a high skilled team as opposed to an unskilled team. Second, with probability p_T+p_M the agent is able to become the skilled partner in a mixed team and attain an extra surplus amounting to $a^e-\underline{a}$. Third, with probability p_T the agent is able to obtain the return from training herself. These returns are offset against the surplus the agent attains when entering a mixed team as an unskilled partner with probability p_{NT}.

In the following, we focus on a steady-state, where $a=a^e$, $b^e=b(\delta^e)$, $\delta^e=T^e/2$ and $T^e=T$. As before, the probability of finding a trainee is given by $p_T=\lambda$. The probabilities p_M and p_{NT} depend on the net supply of skilled workers (as opposed to unskilled workers). We thus need to distinguish two cases.

Case 1 $T\geq(1+\lambda)/2$ with an excess supply of skilled workers. Here, unskilled workers are always able to join a mixed team, implying $p_{NT}=1$. In contrast skilled workers are only able to join with probability $p_M=(1-T)(1+\lambda)/T$. We then obtain $p_T+p_M=(1-T+\lambda)/T$. The share of young workers λ thus affects the net return to training as in (9) through two channels. As in the case with segregated teams a greater share of young workers increases the probability of being able to sell training; however, in addition to this, a greater share of young workers also increases the probability of becoming the skilled partner to a mixed team and, thereby, capture a transfer a^e.

Case 2 $T\leq(1+\lambda)/2$ with an excess supply of unskilled workers. Here, skilled workers are always able to join a mixed team (with or without training), implying $p_T+p_M=1$. In contrast, unskilled workers are now able to join a mixed team only with probability $p_{NT}=(1-\lambda)T/[(1-T)(1-\lambda)]$. Again, it is readily verified that a greater λ tends to increase the net return to training through two channels. As before, it implies a higher probability of finding a trainee and it lowers the opportunity cost of training as an untrained worker now faces a lower probability of being able to join a mixed team with a skilled partner.

Reversing the above argument, we now find that ageing (i.e., a lower λ) has a negative impact on the expected returns to skills in both the market for training and in the market for mixed teams. Within an ageing profession there are both poorer prospects of finding trainees and poorer prospects of finding unskilled workers as 'cheap' partners.

4.2.1 Training in the Presence of Price Competition

Price competition may arise in either or both of the markets for mixed partnerships and for training. We begin by considering the allocation of training when there is price competition with respect to b, while taking as given the price a. We will subsequently study the impact of (further) price competition with respect to a. As a shrinking population implies an excess supply of potential trainers in a steady-state,

perfect competition for trainees implies that $b=b(\delta,a)$ both now and in the future. The surplus from the supply of training is extracted to the point that skilled agents are indifferent between supplying training or taking on a junior partner in a mixed team. But then we obtain

$$\overline{\pi}_y\left(\underset{-}{\delta},\overset{+}{a},\underset{-}{T},\overset{+}{\lambda}\right)=\pi_y\Big|_{T\geq\frac{1+\lambda}{2}}=-\delta+\varrho\left[\underline{a}+a+\frac{1-T+\lambda}{T}\left(a-\underline{a}\right)\right] \qquad (10a),$$

$$\underline{\pi}_y\left(\underset{-}{\delta},\overset{+}{a},\underset{-}{T},\overset{+}{\lambda}\right)=\pi_y\Big|_{T\leq\frac{1+\lambda}{2}}=-\delta+\varrho\left[\overline{a}+a+\frac{(1-\lambda)T}{(1+\lambda)(1-T)}\left(\overline{a}-a\right)\right] \qquad (10b),$$

where $\underline{a}=(\theta_{h,h}-\theta_{l,h})/2$ and $\bar{a}=(\theta_{l,h}-\theta_{l,l})/2$. As one would expect the net surplus from becoming trained increases in a irrespective of whether or not the equilibrium rate of training generates a surplus or shortfall of skilled workers. Furthermore, in both cases the net surplus from receiving training falls in the rate of training and increases in the reproduction rate λ. Again this is intuitive. A higher rate of training implies more competition between (future) skilled agents, thus lowering the probability of becoming the skilled partner in a mixed team and acquiring the associated surplus. Likewise a higher rate of reproduction increases the number of unskilled partners and, thus, the probability of a (future) skilled agent to lead a mixed team.

Training will only be demanded by young agents whose individual training cost δ is low enough to guarantee that the expressions in (10a) and (10b), respectively, are non-negative. One can thus derive the decentral structure of training as

$$T^D(a,\lambda)=\begin{cases}\underline{T}^D(a,\lambda)\ \text{if}\ \varrho\leq\dfrac{1+\lambda}{2\left(\theta_{l,h}-\theta_{l,l}\right)}\\ \underline{T}^D(a,\lambda)\ \text{if}\ \varrho\in\left[\dfrac{1+\lambda}{2\left(\theta_{l,h}-\theta_{l,l}\right)};\dfrac{1+\lambda}{2\left(\theta_{h,h}-\theta_{l,h}\right)}\right]\ \text{and}\ a\in\left[\underline{a};\dfrac{1+\lambda}{4\varrho}\right]\\ \overline{T}^D(a,\lambda)\ \text{if}\ \varrho\in\left[\dfrac{1+\lambda}{2\left(\theta_{l,h}-\theta_{l,l}\right)};\dfrac{1+\lambda}{2\left(\theta_{h,h}-\theta_{l,h}\right)}\right]\ \text{and}\ a\in\left[\dfrac{1+\lambda}{4\varrho};\overline{a}\right]\\ \overline{T}^D(a,\lambda)\ \text{if}\ \varrho\geq\dfrac{1+\lambda}{2\left(\theta_{h,h}-\theta_{l,h}\right)}\end{cases}.$$

with

$$\underline{T}^D\left(\overset{+}{a},\overset{+}{\lambda}\right):=T^D\Big|_{T\leq\frac{1+\lambda}{2}}=\frac{1}{2}+\frac{\varrho\left(\overline{a}+\lambda a\right)}{1+\lambda}-\sqrt{\left(\frac{1}{2}+\frac{\varrho\left(\overline{a}+\lambda a\right)}{1+\lambda}\right)^2-\varrho\left(\overline{a}+a\right)}$$

and

$$\overline{T}^{D}\left(\overset{+}{a},\overset{+}{\lambda}\right) := T^{D}\Big|_{T\geq\frac{1+\lambda}{2}} = \varrho\underline{a} + \sqrt{(\varrho\underline{a})^{2} - \varrho(1+\lambda)(a-\underline{a})}\,.$$

It can be checked that the rate of training increases both in the transfer a and in the rate of reproduction λ, where an increase in either of the two implies a higher (expected) future return to training. Thus, in this case, too, a shrinking population implies a lower rate of training. Comparing the decentral rate of training with the profession's optimum as described in (4), one can establish the following.

Lemma 1. (i) $\underline{T}^{D}(a,\lambda) < T^{S}$ for all $a<min\{\tilde{a};(1+\lambda)/(4\varrho)\}$ and $\underline{T}^{D}(a,\lambda) = T^{S}$ for $a=min\{\tilde{a};(1+\lambda)/(4\varrho)\}$. *(ii)* $\overline{T}^{D}(a,\lambda) > T^{S}$ for all $a>max\{\underline{a};(1+\lambda)/(4\varrho)\}$ and $\overline{T}^{D}(a,\lambda) = T^{S}$ for all $a=max\{\underline{a};(1+\lambda)/(4\varrho)\}$.

Thus, there is scope for under-provision (over-provision) of training, when the discount factor is low (high). Intuitively, a low discount factor implies that the future returns of training are strongly discounted so that only few young agents engage, and should engage, in training to begin with. The resulting under-supply of skilled workers leads to good prospects for those young workers who undertake training to be able to join a mixed team in the future. Nevertheless, and somewhat contrary to intuition, these relatively good expected returns to training are generally insufficient to stimulate the efficient level of demand for training. Thus, there is an under-supply unless the returns to skilled workers within mixed teams take on their maximum values. The converse applies to high levels of the discount factor. Although the excess supply of skilled workers dampens the expected returns to undertaking training, there is still a tendency towards over-supply unless skilled agents receive the minimum fee within a mixed team.

Therefore, the question how the fee for mixed teams without training is determined turns out to be crucial for the efficiency of training. We can envisage several scenarios. For instance, the presence of a minimum wage for unskilled workers implies an upper-bound on a. This would curb a potential over-provision of training in the case of high levels of the discount factor yet exacerbate under-provision in case of low levels of the discount factor. Suppose now that the fee a is determined competitively. Specifically, we would expect a to increase (decrease) whenever there is an excess demand for (supply of) skilled workers, i.e., whenever $T<(1+\lambda)/2$ ($T>(1+\lambda)/2$). The following then applies

$$a = \begin{cases} \bar{a} \Leftrightarrow \varrho \leq \dfrac{1+\lambda}{2\left(\theta_{l,b} - \theta_{l,l}\right)} \\ \dfrac{1+\lambda}{4\varrho} \Leftrightarrow \varrho \in \left[\dfrac{1+\lambda}{2\left(\theta_{l,b} - \theta_{l,l}\right)}; \dfrac{1+\lambda}{2\left(\theta_{b,b} - \theta_{l,b}\right)}\right] \\ \underline{a} \Leftrightarrow \varrho \geq \dfrac{1+\lambda}{2\left(\theta_{b,b} - \theta_{l,b}\right)} \end{cases}.$$

Hence, in situations, where a low (high) discount factor leads to a perpetual under-supply (over-supply) of trained partners, the entry fee into mixed partnerships increases up to the maximum level (decreases down to the minimum level). For intermediate levels of the discount factor, the fee adjusts so as to balance the number of skilled and unskilled workers. Drawing on Lemma 1, we can now establish the following result.

Proposition 3 If both the training fee and the entry fee into mixed partnerships adjust competitively, the resulting allocation of training is efficient.

Similar to the case with $\chi>0$ the competition for trainees eliminates all current and future profits from the provision of training. The same does not apply with respect to the entry fee into a mixed team as long as there is not a surplus of skilled workers. Hence, for $T\leq(1+\lambda)/2$ a skilled agent is able to make a profit by charging an entry fee from unskilled workers. However, competition implies that this profit exactly matches the private return to training with the profession's return. In contrast, for $T\geq(1+\lambda)/2$, unskilled agents are able to make a profit when entering a mixed team. This profit reduces the private net return to training exactly to the level of the profession's return.

5. Conclusions

We have studied private and social incentives to provide training within partnerships under the condition of a shrinking workforce. According to our findings population ageing reduces the total incidence of training (per capita) due to a demographic effect (a lower number of potential trainees per capita) and an economic effect (a lower rate of training). The reason is that the competition for young and/or unskilled partners becomes tougher within an ageing workforce. This tends to erode the returns to training whenever they include the profit from providing training to the next cohort and/or from becoming the senior partner in a mixed partnership. In such a case, the current demand for training drops beyond what would be predicted on the basis of demographics alone.

If the fees for training and, where relevant, the entry fee for unskilled workers into mixed teams are set competitively then training activities tend to be efficient even within a shrinking population. This is because all expected returns to training related to the shifting of surplus from young to old agents and from unskilled to skilled agents are eroded in the competition of skilled-old workers for the lower number of young trainees. Therefore, there are no private rents associated with the acquisition of training and the optimum is attained even in a decentralised setting. If production takes place in mixed teams, a further condition for efficiency is that the entry fee into such teams adjusts competitively to imbalances between the numbers of skilled and unskilled workers.

However, the model also identifies the scope for deviations from the efficient degree of training. Kuhn et al. (2007) consider a situation, where the training fee is the outcome of a bargaining process taking place between representatives of the young and old agents. If bargaining takes place before partners are matched and if the agreed-on fee is uniformly applied to all teams, then an efficient allocation is generally not attained. In this case, an unequal distribution of bargaining power in either direction leads to an under-provision of training. As the strong side to the bargain seeks to extract surplus from their contemporary opponents, this renders unprofitable the provision of training in those teams with high training costs. If bargaining power is equally distributed then contemporary agents seek to extract surplus from the generations of future trainees. Thus, there is a tendency towards over-provision of training. This tendency is weakened in the presence of population ageing / decline where the perpetual shortfall of potential trainees leads to an erosion of the expected returns from selling training. Thus, within an ageing workforce under-provision of training becomes somewhat more likely.

While we have cast our model in terms of training, the idea extends to other forms of investment that are undertaken to attain/maintain a high value of the partnership business. The value of the partnership business may be based on an advanced technology and/or on a reputation for high quality. Thus, the cost δ may reflect (regular) investments in order to replace obsolete technology with a view to remaining efficient and/or maintaining quality. Upon taking over an established (i.e., valuable) business the junior partner will have to compensate the leaving partner for the investments undertaken. However, he or she is the less inclined to purchase the established business (rather than open up a less valuable business on his or her own) the lower the probability that he or she is able to sell on the established business in the future. Within an ageing profession the scope for selling on such businesses declines over time and thereby erodes current investment in future business opportunities.

The model lends itself to a number of extensions. Apart from an analysis of the bargaining problem for the case in which mixed teams are formed, further analysis may take into account the implications of wealth constraints faced by young

partners. Note that the purchase of training may well imply a fee that exceeds their share of output, i.e., $b>(\theta_{l,b}-\delta)/2$. In this case, wealth constraints imply either a maximum bound on the fee or a reduction in the demand for training below the level attained in the absence of wealth constraints. In either case, under-supply of training may occur, giving rise to an obvious policy issue. One way of overcoming wealth constraints may lie in a mechanism, by which training is initially provided at a low fee but young workers repay the (then retired) old workers out of their future earnings. While this would necessitate a three-generation model (two active, one retired) such an analysis may be insightful.

Another issue amenable to extensions arises from our assumption that productivities do not change over time. In particular, this implies that in the absence of training the economy actually loses productivity. Obviously, this runs counter to most empirical evidence. The issue may be resolved by assuming that there is a positive trend on the productivity of young workers, which would capture the progress of education. Our analysis remains valid in the sense that even then the provision of training by skilled old workers would further enhance the capabilities of young workers, generating thus a further productivity gain. We would thus expect the inclusion of a growth trend of productivity into the model not to alter our results dramatically.

Finally, the matching process in our model is frictionless à la Becker (1973). There is naturally scope for extending the model towards frictitious matching à la Shimer and Smith (2000) who extend Becker's (1973) analysis to allow for time-intensive partner search.

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Life Expectancy, Human Capital Accumulation, Technological Adoption and the Process of Economic Growth[1]

Francesco Lancia, Giovanni Prarolo

"The political economy of technological change is only dimly understood. [...] the vigor of youth is followed by the caution of maturity and finally the feebleness of old age. [...] If we are to understand why the fires of innovation die down, we must propose a model in which technological progress creates the condition for its own demise." (Mokyr 1990: 261)

1. Introduction

Over the past century, all OECD countries have experienced an extraordinary change in the economic environment and in all aspects of human life. During this period, Western World has been characterised by a dramatic increase in the longevity of their population, in aggregate and per capita income and in terms of educational attainment. At the same time, the traditional social structure has greatly changed: The share of both educated and retired people has increased significantly and, as a consequence, the proportion of the working population has shrunk.

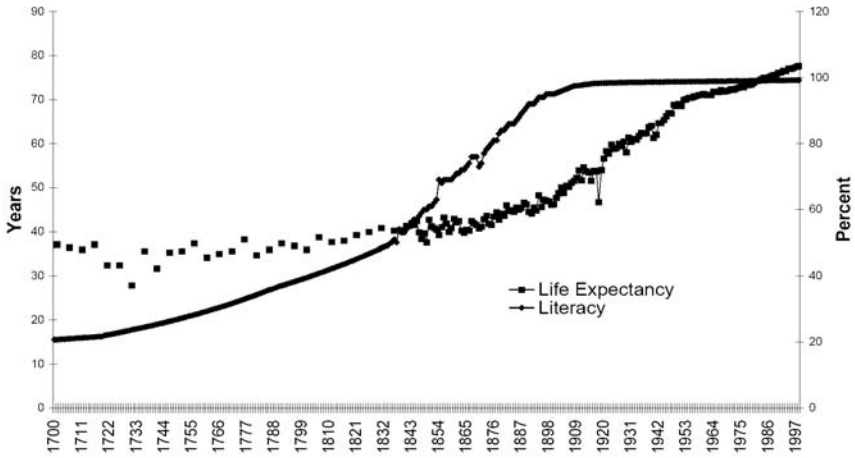
Looking at the details, we can stress some qualitative and quantitative facts behind these features of the mentioned economies. Life expectancy in the last 150 years has increased tremendously: In 1850 it was below 60 years in US (Lee 2001) and around 40 in England (Galor 2005), while today it is close to 80 years in UK (Galor 2005) and 75 in the US (Fogel 1994). At the same time, both the shares of lifetime that people devoted to education and retirement increased. Focussing on

1 The authors would like to thank Carlotta Berti Ceroni, Graziella Bertocchi, Alessio Brown, Matteo Cervellati, Oded Galor, Federico Giammusso, Andrea Ichino, Norbert Kriedel, Alireza Naghavi, Gianmarco Ottaviano, Silvia Stiller for very helpful comments and suggestions, as well as participants at University of Bologna Lunch; 2nd BOMOPA Economics Meeting 2007, University of Padova; 4th Euroframe Conference on Economic Policy Issues in the European Union 2007, Bologna; 10th IZA Summer School in Labor Economics, Munich; 2nd European Workshop "Labour Market and Demographic Change", University of Rostock; HWWI Seminar, Hamburg; for very helpful discussions. All errors are our own.

the US, in 1850 the percentage of people enrolled in primary education was less than 10%. Hence, the time devoted to schooling on average was negligible. Today, adding up informal (domestic education) and formal schooling, people study for around 20 years, i.e., one quarter of their expected lifetime. The participation of people in retirement shows similar trends: In 1850 less than three years were devoted to retirement, while today people enjoy retirement for almost 20 years: again, one quarter of their lifetime (Latulippe 1996). This is especially true for Europe, thanks in particular to the introduction of social security systems after World War II.

Figure 1 explains the evolution of life expectancy and literacy levels for France[2], where the authors use the population able to sign documents to indicate literacy.

Figure 1: Development of Life Expectancy and Literacy



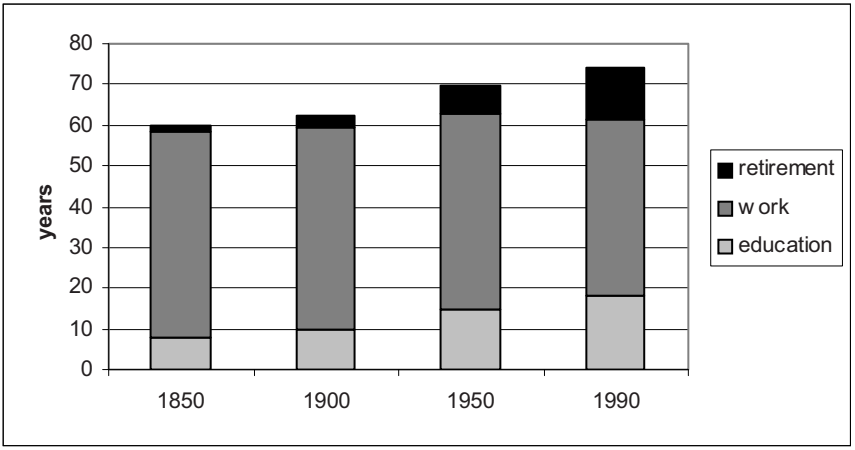
In Figure 2 we show how life expectancy and its components evolved in the US over the past 150 years,[3] in terms of economic roles of people. In Europe some

2 Data are taken from Cipolla (1969) and Floud and McCloskey (1994) and contain literacy for France due to data limitations for England. The pattern of development was qualitatively similar in both countries with France lagging somewhat behind.

3 Source: Lee (2001), www.bls.gov and our calculations.

trends presented here are even more evident: In particular, life expectancy increased more rapidly (from a lower level to a higher level than in the US) and retirement length increased more.

Figure 2: Life Expectancy and Economic Roles in the USA



One of the most important implications of these trends is that developed countries are changing their political structures, moving from a form of "*workers' dictatorship*" - defined as a situation where the mass of the workers represents a large majority in the population - to a more diluted political representation: The voices of both young and retired people in the political debate continually increase, and in principle their interests no longer coincide with the interests of adult workers. This almost certainly influences the composition of the aggregate demand. Consider, for example, the increasing demand for expenditure in health care for elderly people, residential structures for retired people, old age entertainment, etc. Here we are, however, interested in the production side of the economy, specifically in the mechanisms that run from individual and aggregate preferences to the production process and which could be affected by demographic, and therefore political, changes.

A conflict of interests among age classes, in terms of production choices, will probably arise between, on one side, workers and students and, on the other side, retired people. It is the case because the former classes are innovation-prone while the latter is not: They are not interested in technologic innovation since their real income is not tied to their own labour income, which is linked to the past innovation choices. Moreover, a conflict of interests can also arise between young people

and adults: Innovation has long lasting effects for the former, since it affects both their productivity in the labour market once they are adults and their children's capacity to acquire human capital. For the latter, a new technology has an impact on the ability of their children to pay them a pension. These different incentive schemes could hardly be identical.

This analysis addresses the central question of how demographic change affects growth rates of output and national incomes across countries. Since our theory rests on the idea that human capital and technology are the two engines that boost economic growth, we describe how a longer life expectancy affects the dynamics of these two variables. In this framework we analyse, relying on Lancia and Prarolo (2007)'s Three-Periods Overlapping Generation model in which life expectancy endogenously changes the interactions among education, technological change, ageing and growth. The main characteristic of the model is that ageing and human capital accumulation interplay both in the economical and the political arena. This interplay produces innovation and growth which can differ across countries and explains possibly discontinuous phases of development in the same country.

As reported in Figures 3, 4 and 5[4], the cross-section evidences show that while a clear relationship exists between both education and longevity and the level of per capita income and longevity, these evidences lack for the relation between the growth rate of per capita income and life expectancy. This suggests that there might exist an underlying cause that link economic growth and longevity. Thus, our study tries to explain how an economy might evolve when life expectancy influences both private and public choices, and through these channels, productive decisions, technological progress and economic growth.

4 The data has been taken from World Development Indicator (2003), which includes 195 countries.

Figure 3: Life Expectancy and Education

Figure 4: Life Expectancy and Log-GPD per Capita

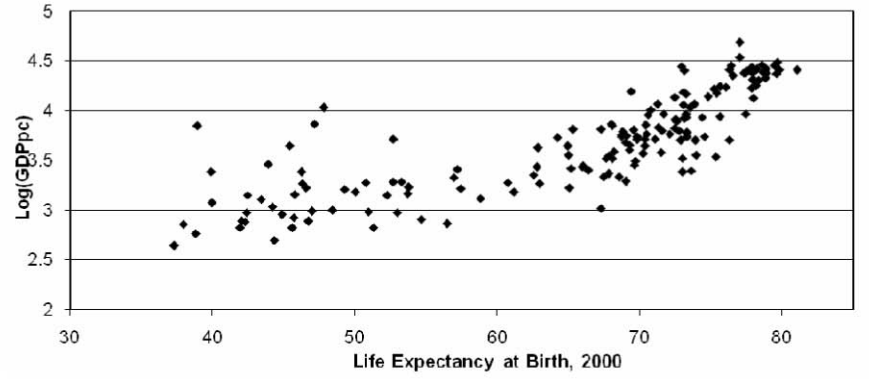
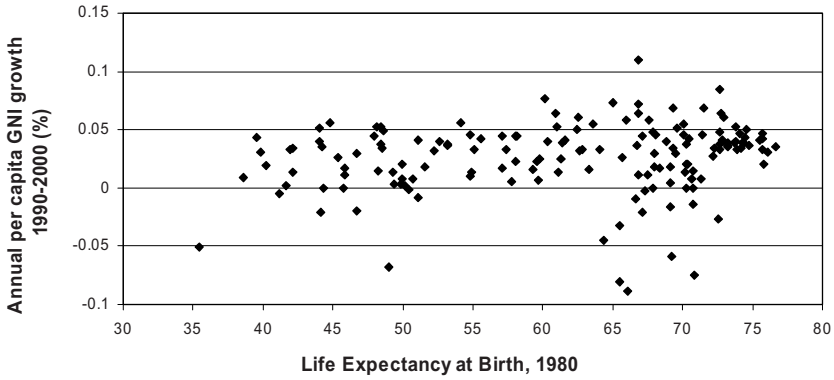


Figure 5: Life Expectancy and Annual GNI per Capita Growth



Thus, unlike De la Croix and Licandro (1999), Boucekkine et al. (2002) and Kalemli-Ozcan (2002), we analyse the impacts of rising longevity on two growth determinants: education and technology. We have in mind the potential conflicts of interests that arise among different generations. Due to different time horizons and economic incentives, individual and aggregate choices can endogenously change because of the demographic evolution of population.

The purpose of this work is to provide an illustration of how an economy might evolve when life expectancy mainly affects both private and public choices concerning the production side of the economy and, therefore, the growth process. The chapter is organised as follows. In Section 2 we review the literature. Section 3 presents the model and the results. Section 4 concludes.

2. Literature

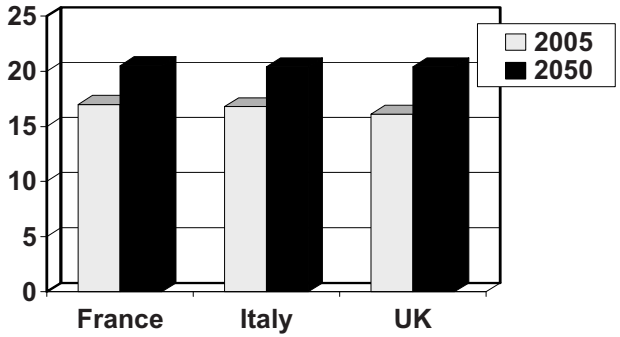
The focus of this work is to jointly tackle issues that nowadays characterise economies. In particular, we are interested in the lengthening of life expectancy, the increase in years spent both in education and in retirement (at the expenses of working years), the shift toward knowledge and human capital intensive productions and the big differences in technological policies among similar countries. The idea is to merge two strands of the literature into a unique theoretical framework: one that studies the interactions among demographic variables (in particular life expectancy) and economic growth, and the other, which explores the politico-economic mechanisms that drive an economy toward different innovation policies.

2.1 Ageing, Human Capital Formation and Growth

The important roles of human capital formation and technological changes for economic growth have been proved, both theoretically and empirically (Lucas 1988, Romer 1986, Mankiw et al. 1992). That is, the improvement of knowledge and skills embodied in labour, as well as changes in technology, mostly embodied in physical capital, determine the potential for moving the production frontier outward. In the last years many authors have started to join this framework of research with a new variable whose importance is being increasingly recognised:

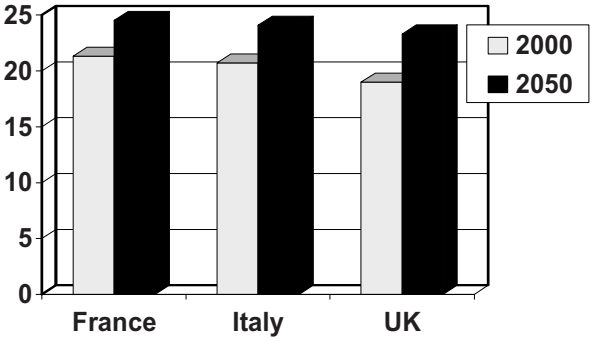
Global Ageing Significant demographic changes are predicted to take place in all industrialised countries over the next 50 years. Looking at demography's future evolution we can say that it will be one of the major determinants of long-run economic development in both industrial and developing countries. The extend of predicted demographic changes will be dramatic and will deeply affect future labour, capital and consumption good markets. This idea is reinforced by observing Figure 6 and 7[5]. They show how life expectancy will evolve in the next 45 years in France, Italy and UK.

Figure 6: Life Expectancy at 65 – Males



5 The data has been taken from Eurostat: http://epp.eurostat.ec.europa.eu.

Figure 7: Life Expectancy at 65 – Females



Another striking projection related to the ageing of population shows up in the ratios between the magnitudes of different age classes. The ratios of people aged 60 and above (Old) to both 20 to 59 year old (Adult) and 0 to 19 year old (Young) are predicted to rise significantly with marked differences across countries as shown in Table 1 for France, Italy and United Kingdom[6].

Table 1: Ratios between Age Classes

Age classes ratios	Old/Young		Old/Adult	
Years	2005	2050	2005	2050
France	0.83	1.21	0.38	0.64
Italy	1.31	1.95	0.45	0.83
UK	0.86	1.26	0.39	0.60

2.2 Technology Adoption

As for the politico-economic mechanisms that drive an economy toward different innovation policies, we focus on the literature on technology that studies implementation rather than the invention of new technologies. The latter literature is based

6 The data used to construct Table 1 and Figure 8 has been taken from Eurostat Population Projections 2007. Calculations are ours.

on the Schumpeterian view of "creative destruction" that takes place among competitive firms or through processes of learning-by-doing and R&D that take place within the firms. The former literature focuses attention on the process that puts an already disposable technology[7] in place and exploits it in the productive process[8]. The analysis is about the costs and benefits of the single actors of the economy and about the conflict of interests that arise among them: With economic units being heterogeneous in different dimensions (consumer vs. producer, old vs. adult, rich vs. poor, etc.), they will rarely be all in favour or against the introduction of a new technology. The decision whether to adopt a new technology or not is rarely the outcome of pure profit-maximising by firms, but comes out from a more complex political and economic mechanism in which different groups (lobbies, governments, productive systems, etc.) act based on their self interests. The crucial point is, therefore, how to find the optimal "social" choice as the reflection of the behaviours of single actors. The public nature of systemic innovation, in contrast with the Schumpeterian view of innovations developed by firms seeking the best cost-saving technology, comes from the historical point of view delineated by economists like Mokyr (1998a, 2002) and Olson (1982). Following this literature, we focus our attention on systemic innovation as a growth-enhancing technology. Bauer (1995) points out that a decentralised market outcome seems to be a poor description of many technology breakthroughs. Economic convenience is certainly not irrelevant, but as Mokyr (1998a) suggests: "*there usually is, at some level, a non-market institution that has to approve, license or provide some other imprimatur without which firms cannot change their production methods. The market test by itself is not always enough. In the past, it almost never was.*" (Mokyr 1998a: 219) Thus, as reported by Olson, adopting a new technology is likely to be resisted by those who lose from it. Such groups engage in activism aimed at influencing the decision by the above-mentioned institutions.

Consequently, according to Lancia and Prarolo (2007) we analyse a framework in which technology adoption is delegated to a regulatory institution for endogenous reasons:

T*he democratic vote* We support the idea that an innovation, before being introduced in large-scale production, has to be approved by some non-market institution. The central authority can be seen as a licensing system where an agency must approve

7 The term "technology" has to be thought in a broad sense: it can include, apart from the usual economic meaning, laws, norms, standardisation systems, productive organisation, etc. that are not productivity-enhancing by themselves, but make the production of new technology easier.

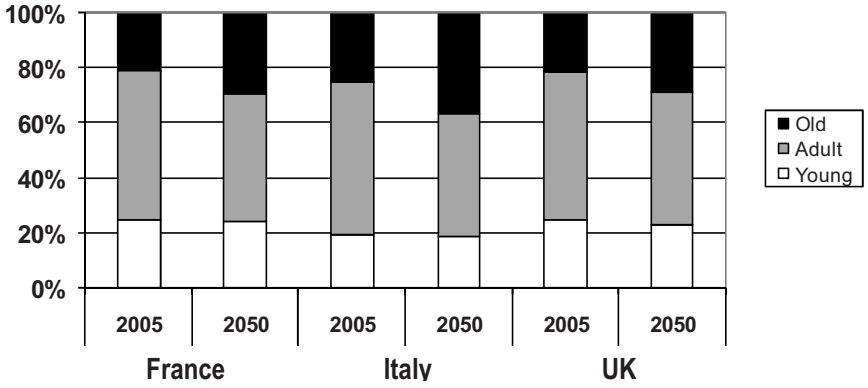
8 Accordingly to Lancia and Prarolo (2007) we take it that there is no uncertainty in the outcome of a new technology of this kind: once the decision to shift to the new technology is undertaken, with probability one a productivity enhancement takes place. It follows that we are not dealing with a risky process of producing new ideas, but with the process of implementing existing ideas in new ways that are more efficient, although not for everybody in the same way.

new technologies before they are brought to the market. Again in Mokyr (1998a)'s words: "*almost everywhere some kind of non-marketing control and licensing system has been introduced*". A recent example is the creation of standard-setting agencies such as the International Organization of Standardization (ISO) or, about property rights, the European Patent Office (EPO).

Among different political mechanisms for implementing a new innovation, we follow Krusell and Rios-Rull (1996) and Aghion and Howitt (1998): A democratic majority voting as a mean of the public choice is needed to prevail the interest of the absolute majority of the population.

For the same countries, we show in Figure 8 how the shares of the three age classes will develop in the next 45 years. It is evident that the fraction of elderly people will increase to the detriment of young and adult population shares.

Figure 8: Shares of Age Classes



Given these facts, economic literature has recently experienced an increasing interest in the cause and implications of an ageing population. The expected strain on public budgets, especially on social security systems, has already received prominent attention. Yet, demographic changes pose many other economic challenges that threaten productivity and growth. In the neo-classical growth theory, population was treated as an exogenous variable that simply grew at a constant, autonomous rate. Accordingly, this theory was silent on the relationship between economic and demographic outcomes and could not address the evidence on the variations in both fertility and mortality rates and life expectancy across different economies or in the same economy over time. The development of endogenous growth theory offered a framework for gaining further insights into the relationship between

population change and economic activity. The major challenge has been to explain demographic transition in fully articulated dynamic general equilibrium models. Only a number of recent works have attempted to study ageing in a model where demographic variables – including variations in longevity – and economic outcomes are determined jointly within an economy, showing, at least theoretically, that economic growth is enhanced by an increase in life expectancy (Galor et al. 1998, Blackburn et al. 2002, Cervellati et al. 2005). In this literature a preeminent idea is that a causal link running from wealth indicators, such as income (or consumption) or human capital, to life expectancy is in place and it is positive. Historians, biologists and economists support this view: Mokyr (1998b) stresses how both centralised innovations (R&D in chemistry, cures against cancer developed in hospitals and research centres, etc.) and knowledge-driven individual behaviours (water sanitation, food storage, personal hygiene, etc.) led to the dramatic rise of life expectancy in the last two centuries. From a theoretical point of view, an increase in life expectancy has always been associated with more time spent in education, more human capital and therefore higher levels (or rates) of economic performance (Kuznets 1973, Ram and Shultz 1979, Kalemli-Ozcan et al. 2000). Only recent contributions have called this conclusion into question: De la Croix and Licandro (1999) and Boucekkine et al. (2002), assuming fixed fertility and using human capital as the sole input in production, introduced vintage human capital to argue that a growth-diminishing effect arises. This is because the more the population ages, the more the human capital used in production depreciates, possibly leading to smaller growth rates. Blackburn and Cipriani (2002), Blackburn and Issa (2002), Castellò-Climent and Doménech (2005) and Cevellati and Sunde (2005) introduce the hypothesis of endogenous life expectancy in the level of human capital to show that multiple equilibria can exist: People living in economies where life expectancy is too short do not find it optimal to invest in human capital. Subsequently, they will get a low level of human capital, preventing the next generation from experiencing an increase in life expectancy. This kind of poverty trap is avoided in a case where initial life expectancy is high enough to permit agents to invest in human capital: This leads to a higher steady state level (or growth rate) in income, generation by generation.

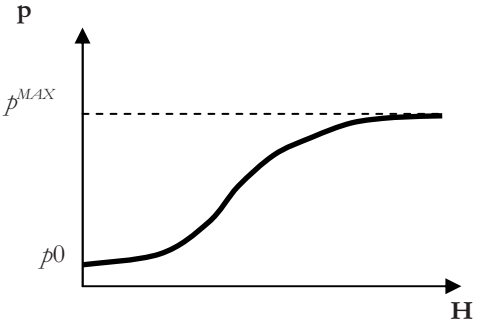
3. The Theoretical Framework

In this section we present a qualitative description of our theory, relying on the technicalities of the model only in the case that it is strictly necessary for a clear explanation of the mechanisms at work. The formal model is developed in Lancia and Prarolo (2007).

3.1 Description of the Economy

Our economy is populated by identical agents living for three periods: youth, adulthood and third age. Agents, during each of these three ages, are characterised by different economic roles. During youth, they choose how long to stay at school and how long to work in an unskilled sector, using the human capital available in the economy at that time (in the form of an externality). Their wage is taxed[9] in case a better, disposable technology is decided to be adopted in the next period, when they reach adult age. Once agents became adult, each of them gives birth to a single child and works in a skilled sector, using the technology that they decided for in the previous period. The wage they get is divided among consumption, a mandatory fixed contribution used to pay their parents' pensions, through a PAYGO fashion, their parents' pension and the potential frictional costs of innovation. People reach third age only with a probability p that can take values smaller than one. The probability p is positively linked to the stock of human capital available in the economy (for a simplified description, see Figure 9), as suggested in many empirical works (Mirowsky et al. 1998, Schultz 1993 and 1998, Mokyr 1998b).

Figure 9: Evolution of Life Expectancy as a Function of Human Capital

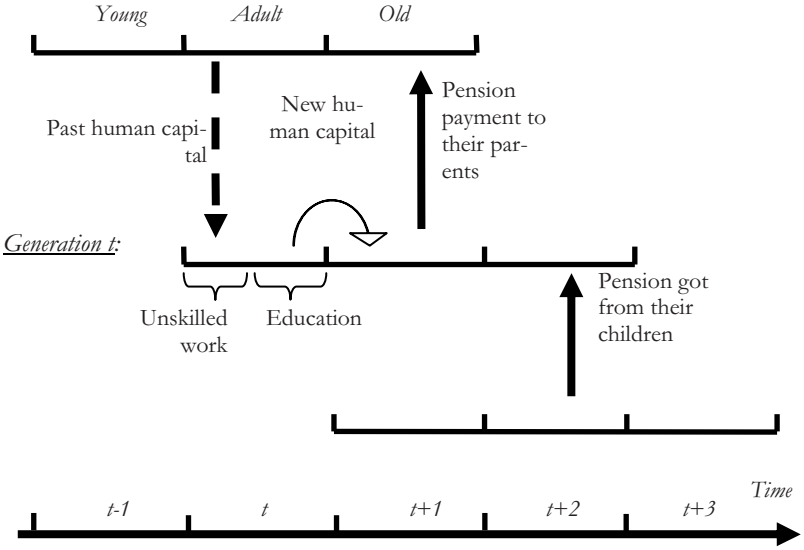


In aggregate terms, an increase in the average probability to reach third age corresponds to an increase of average life expectancy. We can therefore use the term "life expectancy" instead of "probability to survive until third age". People that succeed in reaching third age get a pension paid by their children, disguised as a PAYGO fashion and consume it net of the above mentioned frictional costs of

9 We refer to this tax as the frictional costs of innovation, where needed.

innovation. Figure 10 shows this in a compact way for the generation born at time t (called "Generation t").

Figure 10: Intergenerational Links in the Economy; Example for Generation t



The decision to adopt a new technology is undertaken by means of a majority voting scheme: Whenever an absolute majority of the population votes in favour of an innovation, it is implemented. The productive side of the economy consists of two separate, competitive sectors that use different inputs, skilled and unskilled labour, corresponding to adults and young respectively. A new technology simply augments the total factor productivity in the skilled sector.

3.2 Individual Behaviour

To work when young is necessary in order to consume, since we rule out the case of inheritances from parents. To get education is necessary too, because young people need to acquire some human capital to spend in the labour market when adults. Young therefore choose optimally (as in the Equation 1) how long to work as unskilled ($1-e^*$) and how long to study (e^*), taking into account the productivity of human capital (γ), their willingness to consume in future periods (α), their probabil-

ity to survive until third age (p) and the importance of the available stock of human capital in the production of new human capital (ε). The higher the value of each of these parameters is, the larger will the share of youth time devoted to education be and the higher will the human capital acquired by the agent be (see Lancia et al. (2007) for details).

$$e^* = \frac{\gamma[a + \varepsilon p]}{1 + \gamma[a + \varepsilon p]} \tag{1}$$

Moreover, young people vote on technology adoption. They are more likely to support it (i) the higher the probability is to survive until third age, (ii) the lower the frictional costs relative to the gains in productivity are, (iii) the smaller the depreciation rate of human capital is[10], (iv) the higher their willingness is to consume when they are adults.

Once agents turn to adults, their only choice is what technology to implement. Their incentives to innovate are similar to the ones that drive young people's choice, such as the costs and productivity gains of innovation, the depreciation rate of human capital, etc. Again, the higher their life expectancy is, the higher is their willingness to innovate. There are just two, but remarkable, differences: (i) They are more likely to vote for innovation the lower the pension contributions are that they have to pay for their parents and (ii) their willingness to innovate is negatively related to their preference for today's consumption.

Once retired, people get a transfer from their children and they vote on the adoption of a new technology. Since an innovation is characterised by an upfront cost today and productivity gains only emerge in the future, old people will always vote against.

3.3 Aggregate Behaviour

We use a weighted majority mechanism to aggregate individual choices. We assume that population growth is zero and the number of young people who are born in every period is normalised to one. We also rely on empirical evidence found by Galasso and Profeta (2004) to assume that young people show a lower turnout rate at electoral consultations. Since only a fraction of adults reach third age, the political weight of the eldest class will be p. Calling $\eta<1$ the share of young people that vote

10 The idea is that if young people are trained on a given technology, they develop a vintage of human capital that fits that kind of technology. On the other hand, if a new technology is in place when they became adult, the acquired skills are less useful.

and normalising total population alive in every period to one, we obtain the three shares of young, adult and old voters:

$$\frac{\eta}{\eta+1+p}, \quad \frac{1}{\eta+1+p} \quad \text{and} \quad \frac{p}{\eta+1+p}.$$

The higher the probability p is, the higher is the old's relative political weight and consequently the lower is that of the young and adults in the political decision. It is straightforward to show that, while young and old people can not impose their own political agenda alone (meaning that their relative weights are always smaller than ½), adults' vote will be decisive in the case $p<1-\eta$. We define this case "workers' dictatorship" and it arises in case of a short life expectancy. Conversely, whenever $p>1-\eta$, we use the term "diluted power" because the decision to adopt a new technology needs the support of a coalition of two different age classes, namely the young and the adults.

Figure 11: Political Outcome - The Hatched Areas Represent "Innovation"

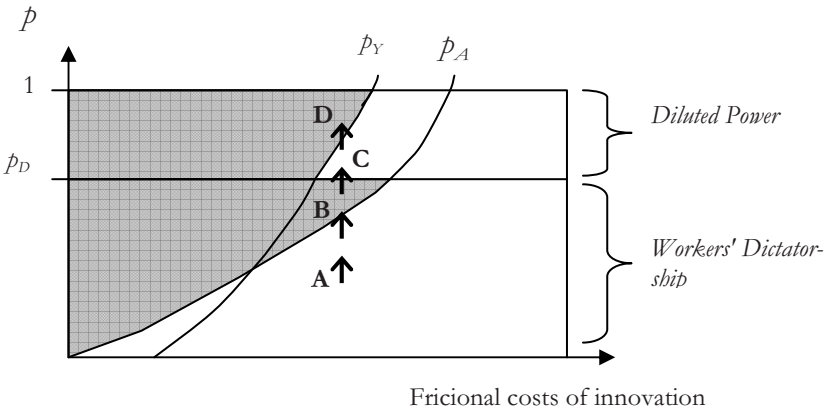


Figure 11 shows graphically how the choices of agents sum up for given parameters' values, taking into account the description above. The curves p_A and p_Y represent the value of p above which adults and young people vote in favour of innovation, respectively. $p_D=1-\eta$ represents the value of life expectancy below which we have the stage called "workers' dictatorship". The areas indicate the combinations of frictional costs and life expectancy that lead to an aggregate choice of innovation.

In Table 2 we resume how the parameters that characterise our economy impact on the thresholds depicted in Figure 11. A "+" means that an increase in the parameter makes p_i shift upward, leading to a lower propensity to innovate for the age class i (with i={Y;A;O}).

Table 2: Partial Effects of Parameters on the Thresholds

	pA	pY	pD
Political weight of young people	0	0	-
Willingness to consume in future periods	+	-	0
Productivity gains from innovation	-	-	0
Frictional costs of innovation	+	+	0
Depreciation of human capital due to innovation	+	+	0
Productivity of human capital in final good production	+	+	0
Elasticity of past human capital in the production of new h.c.	0	+	0
Share of adults' income used to pay parents' pensions	+	0	0

In Figure 11 we also plot a scattered line passing through four regions, A to D, representing different development regimes of the economy. To this end we will show a comprehensive example in the next section, together with the long run dynamic of human capital.

3.4 The Long Run

The optimal individual choice of education and the period-by-period centralised decision about technology adoption define how the economy evolves in the long run. Since no interactions run directly between human capital and agents' preferences about innovation, we can separately study the two issues.

We now focus on the young's optimal choice on schooling time and the impact of this decision on human capital accumulation. From Equation 1 we know that the longer life expectancy at some point in time is, the more young have an incentive to study. Through a standard production function that includes the past level of human capital in its inputs, e^* converts into human capital (Equation 2) useful in the labour market in the next period.

$$h_{t+1}=\Pi(h_t,p_t) \quad (2)$$

Once we introduce the causal effect going from human capital stock to life expectancy, we can rewrite the accumulation function of human capital as a function of past human capital alone:

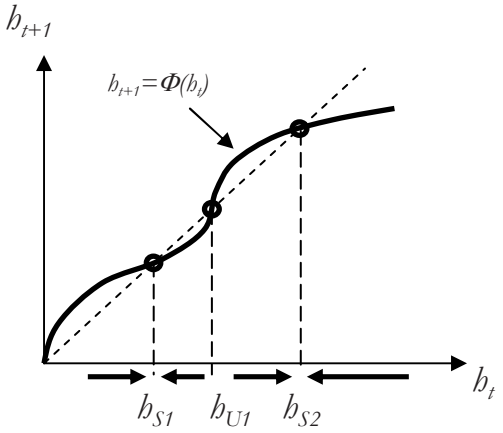
$$h_{t+1}=\Phi(h_t) \quad (3)$$

The resulting function shows the shape depicted in Figure 12: An inflection point is plausible whenever the relation linking the life expectancy to the level of human capital is steep enough[11]. In the case an inflection point exists, it is possible, as Figure 12 shows, that two stable and one unstable steady states arise. Countries in which initial life expectancy is particularly low (below h_{U1}) will be trapped in the lower steady state h_{s1}, while initially more aged economies (above h_{U1}) will reach the higher steady state h_{S2}.

On top of the individual behaviour about education choices, in every period the economy as a whole decides on the adoption of a new technology. In order to rule out the trivial analysis of the poverty trap case we now assume that either a unique stable steady state exists or that the economy starts above h_{U1}. Referring again to Figure 11, we now describe an economy characterised by an initial short life expectancy and intermediate frictional costs. Its graphical representation is point A. Here life expectancy is below both p_D and p_A, so adults alone decide not to innovate. Human capital, however, accumulates and life expectancy in turn increases. This occurs for some periods, then the lengthening of life expectancy makes adults prefer innovation (B): The economy experiences some periods during which both human capital and production (the latter at a higher speed than the former) grow. Then life expectancy exceeds the threshold p_D: At this time adults lose the absolute majority and young, being against innovation $p<p_Y$, force "no innovation" (C) to be the political outcome. Here the economy evolves, again showing increases in both human capital and final good production level, but at the same pace. Once young also feel the net benefits of innovation (D), the economy reaches the upper bound of life expectancy $\bar{p}$, the higher steady state of human capital, the schooling time and the production of final goods increase at a constant, positive rate.

11 For a technical treatment of this issue, please refer to Blackburn and Cipriani (2002).

Figure 12: Human Capital Accumulation Function.



The aim of this exercise is not to show the real evolution of a given economy, but to understand which are the political and economic forces that lead the economy towards its destiny: To understand the type and the timing of the policies that need to be implemented is crucial when constraints on human capital accumulation and/or innovation are in place.

4. Conclusions

Most countries in the world are experiencing dramatic transformations in their economic, demographic and social conditions. In the descriptive section of this chapter we focus on the evolution of life expectancy, education and economic growth. We find it interesting that, despite data show a positive relation between life expectancy and human capital as predicted by economic theory, this link does not lead to a higher growth rate of GDP per capita. It could be explained by several causes, such as the missing of endogenous growth mechanisms or institutional differences among countries. We propose a theoretical framework that builds, on the one hand, on a deeper view on the data while, on the other hand, relies on the political economy literature about technology adoption.

Data show that, apart the increasing life expectancy and educational attainment, economies are experiencing a dramatic upward shift in the median age of populations, resulting in an expanding third age population and shrinking adult and young population shares. Projections for the year 2050 show that these trends will

bring population aged 20 to 59 to be less than one half in some countries, like for example Italy. We link this empirical evidence, for the first time in the literature, to the vast literature on technology adoption. As reported by Olson (1965) and Mokyr (1990), among others, the implementation of new technologies is rarely based on pure profit maximising behaviour, while it is the outcome of centralised decisions involving several actors in the society. In their spirit, we jointly analyse the impact of population ageing on both human capital accumulation, through education, and choices about technology adoption. Despite, we rule out cross effects between human capital accumulation and technology adoption, rich dynamics can arise. That is because the ageing of population affects private incentives about education and centralised incentives about technology adoption in different ways. About the former effect, we find a positive effect running from life expectancy to education, but a possible poverty trap can arise due to a reverse, positive effect as in Blackburn and Cipriani (2002). About the latter, the increase of life expectancy, eventually, leads young and adults to be in favour of technology adoption. Moreover, the innovation path can be discontinuous, because on top of the incentives that characterise every age class, their relative weights in the political arena evolve toward less relative power in the hands of younger generations: If, in relatively young societies, adults alone are able to set the innovation agenda, in relatively aged ones a coalition between adults and young needs to be formed in order to make the adoption of innovations sustainable.

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High Skilled Immigration and Native Educational Decisions

Christian Lumpe, Benjamin Weigert[1]

1 Introduction

Most of the theoretical literature on immigration argues that low skilled immigration raises incentives for natives to invest into human capital which results in a positive welfare effect for the native population (Fuest et al. 2001).[2] However, in many industralised countries the introduction of a skill-selective immigration policy is debated while in others this policy had been implemented. Our subsequent analysis gives a rationale for a skill-selective immigration: In an economy characterised by a frictional labour market and native underinvestment in human capital a skill selective immigration policy is able to foster human capital acquisition of natives.

We present a search-theoretic model of the labour market with endogenous human capital investment of natives. Because the human capital investment decision has to be taken at the beginning of working life, the existence of search frictions on the labour market leads to underinvestment in human capital (Acemoglu 1996, Moen 1998, Sato et al. 2003).We combine this strand of the literature with the immigration literature by considering immigration in terms of the total flows (amount of immigrants) and its characteristics (amount of human capital). Mostly related to our approach is Ortega (2000) who also uses a search-theoretic model but discusses migration patterns in a two-country model and its influence on wages and employment. The solely consideration of the host country gives us the possibility to compare our results with the results from previous studies on immigration, human capital and labour market frictions (see Fuest et al. 2001)

Besides the endogenous human capital investment of natives, our modelling approach accounts for the empirical fact that immigrants return to their home

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2 We concentrate on the impact of immigration on the labour market outcome of natives. There is also a strand of the literature which analyses the consequences of immigration on the educational decision of natives and on the welfare system (see Kemnitz 2004).

country.[3] Introducing the possibility of return migration leads to a higher job destruction rate (shorter employment spells) for immigrants than for natives. As a partial result, our model can explain two stylised facts of the labour market: first, immigrants with the same human capital endowment earn lower wages than natives. Second, the unemployment rate of immigrants is higher than the unemployment rate of natives. Immigrants are therefore discriminated ex-post against natives because of their higher probability to leave the match.[4] This has to be distinguished from ex-ante discrimination, because in our model firms do not offer vacancies which are specific to immigrants or natives.

Our main result is that an immigration policy aiming at well-educated immigrants makes it more profitable for firms to increase the number of jobs and advertise more vacancies which in turn increases the wage paid by firms. Higher wages paid per unit of human capital make it more sensible for natives to invest into human capital. Therefore, high skilled immigration leads to rising educational attainment of natives. This is in contrast to the existing literature of immigration and human capital which shows that low skilled immigration may raise educational attainment of natives (see Fuest et al. 2001). Consequently, our result can be seen as an argument in favour of introducing a rather skill-selective immigration policy as discussed currently in many European countries.[5]

The remainder of the paper is structured as follows: in Section 2 we present the basic structure of the model. In Section 3 we derive both the solution of the individual human capital investment decision problem and the equilibrium. Section 4 concludes.

2 Basic Model

2.1 Households

We develop an equilibrium matching model of the Diamond-Mortensen-Pissarides type (Pissarides 2000). The economy is populated by a mass one of identical, risk-neutral, native workers $N = 1$ and foreign workers (immigrants) $I \geq 0$ adding to a total population $L = 1 + I$.[6] All individuals and firms discount future payments at the common discount rate ρ. Native workers enter and exit the labour market at a

3 For a detailed theoretical and empirical discussion about return migration see Dustmann (2003). Müller (2003) also introduces return migration in an efficiency-wage model.

4 This kind of discrimination is similar to the analysis of Müller (2003).

5 The UK has already introduced a point-based immigration law which has been geared towards the immigration laws of New Zealand and Australia.

6 Throughout the paper subscript N denotes natives and subscript I denotes immigrants.

constant rate $\delta_N > 0$ such that the number of native workers is constant over time.[7] The number of potential immigrants is normalised to one which simplifies the exposition of the model. Immigrants enter a country's labour market at rate $\mu > 0$ and leave the labour market due to retirement ($\delta_N > 0$) or migration back to the home country ($r > 0$). The total exit rate of immigrants adds to: $\delta_I = \delta_N + r$.[8] The net flow of immigrants can therefore be calculated as $\dot{I} = \mu - \delta_I I$. The steady state number of immigrants ($\dot{I} = 0$) in the host country is $I = \mu/\delta_I$. To simplify the exposition of the model, we denote the immigrants share in total population by $\eta_L = I/(1 + I) = \mu/(\delta_I + \mu)$.

Both, native and immigrant workers start their working life in the unemployment pool. Before entering the unemployment pool, native workers have to decide about their human capital investment $z_N > 0$. Once taken, the educational decision is irreversible. The cost per unit of human capital z_N amounts to c and the total cost of education cz_N will be borne by workers.

Immigrants entering the labour market are assumed to be endowed with human capital z_I which they already acquired in their home country. We assume that there exists no principal difference between the quality of human capital of natives and immigrants.[9] The acquired human capital can be used by any firm meaning that firms make no differences between an immigrant and a native worker.[10] The difference of endowments of human capital between natives and immigrants will only be reflected in the wages paid by firms.

Natives and immigrants can be in two different states: They are either working or searching for a job. Hence, we abstract from on-the-job search.

2.2 Matching

We denote the number of unemployed workers by u and the number of vacancies searching for a worker by v. The ratio $\theta = v/u$ is then called labour market tightness. The random process by which vacancies and unemployed workers find each other

7 The rate δ_N is the birth and retirement rate in the economy.

8 In our model the return rate r is assumed to be exogenous. Typically, the decision to return to the home country is taken by the immigrant. However, in most industrialised countries we observe a large return migration which justifies our assumption of r>0.

9 At least at the beginning, the human capital quality of immigrants will differ from the human capital of natives (e.g., by language proficiency) but including this assimilation process would only strengthen the results of the model.

10 See Bowlus and Eckstein (2002) or Black (1995) for discrimination in search models.

is represented by a matching function: $m(u, v) > 0$ with $u, v > 0$. The matching function denotes the number of matched vacancies and workers per unit of time.[11]

The application arrival rate for vacant jobs $q(\theta)$ can then be written as: $q(\theta) = m(u, v)/v = m(1/\theta, 1)$ with $q'(\theta) < 0$ and $\lim \theta \to 0\ q(\theta) = \infty$, $\lim \theta \to \infty\ q(\theta) = 0$. An unemployed worker meets a vacant job at the rate $p(\theta) = m(u, v)/u = \theta q(\theta)$ with $p'(\theta) > 0$ and $\lim \theta \to 0\ p(\theta) = 0$, $\lim \theta \to \infty\ p(\theta) = \infty$. Native workers and immigrants meet a vacant job at the same rate. Note that potential firms cannot directly search either a native worker or an immigrant worker. Whether it is a native worker or an immigrant will be revealed when a firm and a worker meet.

2.2.1 The Beveridge Curve

The flow equation of umployment $\dot{u}_i$ i=I, N which characterises the labour market is the difference between the inflows into unemployment and the outflows from unemployment. With both natives and immigrants being in the pool of unemployed workers we have two different flow equations for each group $\dot{u}_N$, $\dot{u}_i$ Inflows into unemployment occur if a job is closed or new workers enter the labour market. Any filled job can be destroyed due to two different reasons: either the job is hit by an exogenous negative productivity shock at rate s or the job is closed because the employee leaves the labour market completely which occurs at rate δ_i, $i = I, N$. Note that only the former increases the number of unemployed. The respective dynamics of unemployment are given by:

$$\dot{u}_N = \delta_N + s(1 - u_N) - p(\theta)u_N - \delta_N u_N \tag{1}$$

$$\dot{u}_I = \mu + s(I - u_I) - p(\theta)u_I - \delta_I u_I \tag{2}$$

In the steady state $\dot{u}_i = 0, i = I, N$, we obtain the following number of unemployed native[12] and immigrant workers:

$$u_N = \frac{\delta_N + s}{s + p(\theta) + \delta_N}, \quad u_I = \frac{\mu}{\delta_I} \frac{\delta_I + s}{s + p(\theta) + \delta_I} \tag{3}$$

11 The matching function m (u, v) is assumed to be twice continuously differentiable, homogeneous of degree one and exhibits the following properties: $m(0,v) = m(u,0) = 0$, $\delta m/\delta u$, $\delta m/\delta v > 0$, $\delta^2 m/\delta u^2$, $\delta^2 m/\delta v^2 < 0$.

12 Because the number of natives is standardised to one, the number of unemployed natives is also the unemployment rate of natives.

with $u_N \in [0,1]$ and $u_I \in [0, \mu/\delta_I]$. The aggregated Beveridge curve of the economy is then given by the sum of unemployed natives and immigrants:

$$u = \frac{\delta_N + s}{s + p(\theta) + \delta_N} + \frac{\mu}{\delta_I} \frac{\delta_I + s}{s + p(\theta) + \delta_I}. \quad (4)$$

Comparing the unemployment rates of natives and immigrants we arrive at the following result:

Corollary 1. The unemployment rate of immigrants is always higher than the unemployment rate of natives: $u_N < u_I/I$.

Proof. Using equation (3) together with the definition of the unemployment rate it follows that $u_N < u_I/I$.

Consequently, the immigrants' share in unemployment is always greater than the immigrants share in total population:

$$\eta_U(\theta) = u_I / (u_I + u_N) > I/(1+I) = \eta_L(\theta).$$

Therefore, our model features a well documented fact of labour markets in most industrialised countries (Hatton et al. 2005: 325 Table 15.3).[13]

2.2.2 Match Formation and Wage Setting

Let U_i, W_i, $i = I,N$ be the expected present value of unemployment and employment, respectively. Then the flow value (asset value) of unemployment is given by:

$$\varrho U_i = b + p(\theta)(W_i - U_i) - \delta_i U_i, \quad i = I, N \quad (5)$$

An unemployed worker receives the instantaneous value of leisure b and will meet a vacant job at rate $p(\theta)$, thereby swapping the value of unemployment U_i with the value of employment W_i. At the rate δ_i an unemployed worker is expected to leave

13 Interestingly, most of the empirical literature concentrates on the explanation of wage differentials between natives and immigrants. There are very few papers analysing immigrants' incidence of unemployment (McDonald et al. 1997 for Canada, Arai et al. 2004 for Sweden).

the labour market and therefore loses the value of unemployment U_i.[14] By the same argument the flow value of an employed worker can be written as:

$$\varrho W_i = w_i + s(U_i - W_i) - \delta_i W_i \quad , i = I, N. \tag{6}$$

While being employed a worker receives instantaneously the wage w_i. The job is expected to be closed at rate s and the worker enters the unemployment pool. Additionally, a job is randomly closed according to the retirement rate δ_i, $i = I, N$.

Now, we look at the expected present value of firms, which are either producing or searching for a worker. A firm searching for an applicant incurs search cost $k > 0$ at each instant of time. Note that a job can either be filled with a native worker or an immigrant worker. As mentioned before, apart from the differing retirement rates, the only potential difference between both types of workers is the endowment with human capital z_i, $i = I, N$.

The output of a job-worker pair is generated according to a general production function $f: R^+ \rightarrow R^+$ with human capital z being the only input of production. The production function has the following properties: $f'(z) > 0$, $f''(z) < 0$, $\lim z \rightarrow 0\, f'(z) = \infty$ and $\lim z \rightarrow \infty\, f'(z) = 0$. Furthermore, we assume that for any $z = 0$ the value of output is strictly greater than the value of leisure b: $f(z) > b$.[15]

Let V, J_i, $i = I,N$ be the expected present value of a vacant job and a filled job, respectively. The flow value of a producing firm with workers $i = I, N$ is given by:

$$\varrho J_i = f(z_i) - w_i + (s + \delta_i)(V - J_i), \quad i = I, N.$$

The flow value consists of the flow profits of a match $f(z_i) - w_i$ and the potential loss caused by either the destruction of the job (with rate s) or the retirement of the respective worker (with rate δ_i).

For the derivation of the flow value of a vacancy V it is important to bear in mind, that ex-ante a firm does not know whether it will produce with a native worker or an immigrant worker. The share of unemployed immigrants of the pool of unemployed workers $\eta_U(\theta)$ also reflects the conditional probability of meeting an immigrant job searcher. The effective rate of meeting an unemployed immigrant is $q(\theta)\eta_U(\theta)$ while the effective rate of meeting an unemployed native is given by: $q(\theta)(1-\eta_U(\theta))$. We assume that the effective rate for any group is negatively correlated

14 For simplicity, we assume that the value of returning to the home country is zero for immigrants. In any case, the value of returning home should be smaller than the value of unemployment.

15 Without this requirement a situation can arise where no individual chooses to educate and work.

with labour market tightness θ such that $dq(\theta)(1-\eta_U(\theta))/d\theta<0$ and $dq(\theta)\eta_U(\theta)/d\theta<0$ holds.[16] Any firm offering a vacant job considers the expected present value of a filled job $J^e = \eta_U J_I + (1-\eta_U) J_N$.[17] The flow value of a vacant job can then be written as:

$$\varrho V = -k + q(\theta)(J^e - V)$$

and consists of the flow costs of searching k and the potential change from a vacant to a productive job (J^e - V). Free entry of firms generates an asset value of a vacancy of zero: $V_i = 0$. Thus we can calculate the job creation condition of firms as:

$$J^e = \frac{k}{q(\theta)}. \tag{7}$$

Free entry leads to an expected present value of a filled job J^e which is equal to the expected costs of finding a worker. We also get the following expression for a filled job of type i:

$$J_i = \frac{f(z_i) - w_i}{\varrho + \delta_i + s}, \quad \text{i = I, N} \tag{8}$$

We assume that wages are negotiated between a matched worker-firm pair according to Nash-bargaining. This means that the wage for worker type i solves the following optimisation problem:

$$w_i = \arg\max (W_i(w_i) - U_i)^{\beta} (J(w_i) - V)^{1-\beta}, \quad i = I, N \tag{9}$$

where β is interpreted as the bargaining power of workers.[18] The wage setting function for each type of worker is given by:[19]

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16 This assumption ensures that the composition effect in the pool of unemployed cannot dominate the effect of increased labour market tightness. Otherwise, an increase in labour market tightness might decrease the effective rate of meeting an unemployed immigrant while at the same time increasing the effective rate of meeting an unemployed native.

17 For notational convenience we drop the functional argument θ in $\eta U(\theta)$ when this causes no confusion.

18 By using this formulation we assume that there is no difference in the bargaining power of natives and immigrants. Presumably the bargaining power of immigrants is lower compared to natives at the beginning of their working life in the host country and the same in the long run. However, taking this into account would not alter the results of the model qualitatively.

19 The derivation of (10) can be found in the appendix.

$$w_i = \beta f(z_i) + (1-\beta)\frac{b(\varrho+\delta_i+s) + p(\theta)\beta f(z_i)}{\varrho+\delta_i+s+p(\theta)\beta}, \quad i = I, N \tag{10}$$

Comparing both, the wage of natives and immigrants, yields the following result:

Corollary 2. Immigrant workers with human capital $z_I \leq z_N$ always earn a lower wage $w_I < w_N$ compared to a native worker.

Proof. Taking the total differential of the native wage equation we get:

$$dw_N = -\frac{(1-\beta)\beta p(\theta)\left(f(z_N)-b\right)}{\left(\varrho+\delta_N+s+p(\theta)\beta\right)^2}d\delta_N + \frac{(1-\beta)\beta p(\theta) f'(z_N)}{\varrho+\delta_N+s+p(\theta)\beta}dz_N < 0$$

Evaluating the total differential at $d\delta_N = r$ and $dz_N \leq 0$ completes the proof.

This result stems from the fact that immigrants have a higher risk of leaving the host countries' labour market. A higher risk of closing a productive job translates into a lower average job duration which reduces the potential surplus of the job. Therefore the wage rate, a share of the total surplus, has to be smaller to compensate for this lower duration.[20]

For future reference, it will be convenient to derive closed form solutions for U_i and J_i, $i = N,I$. Together with the wage setting function we derive the expected present value of unemployment in terms of human capital z_i and labour market tightness θ:

$$U_i = \frac{b(\varrho+\delta_i+s) + p(\theta)\beta f(z_i)}{(\varrho+\delta_i)(\varrho+\delta_i+s+p(\theta)\beta)} \quad \text{i = I, N} \tag{11}$$

U_i is a weighted average of the value of unemployment b and the share β of the output $f(z_i)$. Note that z_N is endogenous and will be chosen by natives. Using the expression for the wage rate w_i together with the definition of the expected value of a filled job (8) of type i yields:

$$J_i = \frac{(1-\beta)\left(f(z_i)-b\right)}{\varrho+\delta_i+s+\beta p(\theta)}, \text{ i = I, N} \tag{12}$$

20 There is a huge empirical literature analysing the evident wage differential between natives and immigrants, see e.g., Borjas (1999).

This expression can then be used in the free entry condition (7) to yield the firms' job creation curve (JCC):

$$\eta_U \frac{q(\theta)(1-\beta)(f(z_I)-b)}{\varrho+\delta_i+s+\beta p(\theta)} + (1-\eta_U)\frac{q(\theta)(1-\beta)(f(z_N)-b)}{\varrho+\delta_N+s+\beta p(\theta)} = k \tag{13}$$

This job creation curve is equivalent to the standard formulation in search models except that we have two different types of filled jobs.

3 Educational Decisions and Equilibrium

3.1 Educational Decision

Before entering the labour market, natives must decide how much to invest into education. After the investment decision is made, each new entrant will start as an unemployed worker searching for a job. As the expected present value of unemployment U_N already incorporates any future periods of employment and unemployment, it is the expected total lifetime income of a native worker. Consequently, an individual entering the labour market will seek to maximise U_N by choosing the level of human capital z_N appropriately. Therefore, native workers' optimisation problem is to maximise the net expected value of unemployment:

$$\max_{z_N} U_N - cz_N .$$

Using the closed form of U_N the first order condition for a native worker is given by:

$$\frac{\beta p(\theta)}{(\varrho+\delta_N)(\varrho+\delta_N+s+\beta p(\theta))} f'(z_N) = c . \tag{14}$$

Any native worker chooses investment level z_N as to equalise the marginal return and the marginal costs c. For future reference we will refer to (14) as investment decision condition (IDC). Note that both, a higher retirement rate δ_N and higher destruction rate s decrease the level of human capital investment, because the time period to recoup the investment will be shorter. Additionally and with the same line of reasoning, increased labour market tightness θ increases the investment level, because unemployment spells are shorter. It is important to note that immigration

does not directly influence the individual investment decision. However, immigration influences the equilibrium outcome of the economy in terms of θ and z_N.

3.2 Equilibrium

A competitive equilibrium consists of a triple $\{z_N^E, \theta^E, u^E\}$ which simultaneously solves the job creation condition (JCC) of firms:

$$G_1^E(z_N, \theta) := q(\theta)\left[\eta_U(\theta) J_I(\theta) + (1-\eta_U(\theta)) J_N(\theta, z_N)\right] = k, \tag{15}$$

the investment decision (IDC) of native workers:

$$G_2^E(z_N, \theta) := \frac{\beta p(\theta)}{(\rho+\delta_N)(\rho+\delta_N+s+\beta p(\theta))} f'(z_N) = c \tag{16}$$

and the Beveridge curve:

$$u = \frac{\delta_N + s}{s + p(\theta) + \delta_N} + \frac{\mu}{\delta i} \frac{\delta_I + s}{s + p(\theta) + \delta_I}. \tag{17}$$

Note that the system is block-recursive so that equilibrium values of the labour market tightness θ_E and the human capital z_N^E are completely identified by (13) and (14). Using the resulting θ_E in (4) yields the equilibrium number of unemployed workers u_E. As shown in the appendix, both, the JCC and the IDC are positively sloped curves in the (z_N, θ)-space. The IDC starts at the origin and z_N is bounded from above by $\bar{z}$ according to $\{\bar{z}_N : f'(\bar{z}) = (\rho + \delta_N)c\}$. In contrast, the JCC starts at a positive θ with no upper bound for z_N and θ. It can be shown that both curves intersect at least once such that, at least one, equilibrium exists.[21] Our model exhibits the possibility of multiple equilibria. For reasons to become clear later, we restrict our analysis to stable equilibria only. To define a stable equilibrium, we construct simple out-of-steady-state dynamics. Consider a triple $\{z_N^1, \theta^1, u^1\}$ in a sufficiently small neighbourhood of an equilibrium triple $\{z_N^E, \theta^E, u^E\}$. Assuming that labour market tightness θ will respond fastest to eliminate positive profits from open vacancies, we get a new θ according to $\theta^2 = \theta_{G_1^E = k}(z_N^1)$. This new θ^2 will induce

21 For a detailed proof, please consult the appendix.

workers to revise their investment decision to $z_N^2 = \theta_{G_2^E=\varepsilon}(\theta^2)$. The sketched dynamics create a series $\{z_{iN}, \theta_i, u_i\}_{i=1,\ldots}$ which is stable if it converges to $\{z_N^E, \theta^E, u^E\}$. With this kind of out-of-steady-state dynamics it is obvious that any triple in the vicinity of an unstable equilibrium will lead to an ever increasing or decreasing number of unemployed. We restrict our analysis to stable equilibria, because this kind of trend in the number of unemployed is contrary to facts.

With the characterisation of a stable equilibrium we can show that a stable equilibrium is reached if, at the intersection of both equilibrium conditions, the slope of the IDC is steeper than the slope of the JCC:

$$\left.\frac{d\theta}{dz_N}\right|_{G_1^E=k} < \left.\frac{d\theta}{dz_N}\right|_{G_2^E=\varepsilon}.$$[22]

Figure 1 on the following page illustrates the JCC and the IDC in the (z_N, θ)-space in a situation with a stable equilibrium.

3.3 Comparative Statics Results

In this section we analyse the impact of immigration on the labour market equilibrium. We discuss two different scenarios: first time immigration into a formerly closed economy without any immigration (μ=0) and the case of sustained immigration into an economy with existing immigration (μ>0, z_I >0). Throughout the following sections, we assume that we are in a stable equilibrium. Note that immigration only affects the JCC, while the IDC is unaffected: $G_{2,\mu}^E = G_{2,z_I}^E = 0$.[23] Therefore, we can concentrate on the influence of immigration on the JCC only.

In the case of first time migration, the calculation of the partial effect of z_I on the JCC reveals that $G_{1,z_I}^E\big|_{\mu=0} = 0$. However, the influence of the migration rate μ on the JCC is nonzero such that we derive the following results:

$$G_{1,\mu}^E\Big|_{\mu=0} = \eta_{U,\mu}\Big|_{\mu=0} q(\theta)(J_I - J_N) \quad \begin{cases} > 0 & \text{if } (J_I - J_N) > 0 \\ < 0 & \text{if } (J_I - J_N) < 0, \end{cases} \tag{18}$$

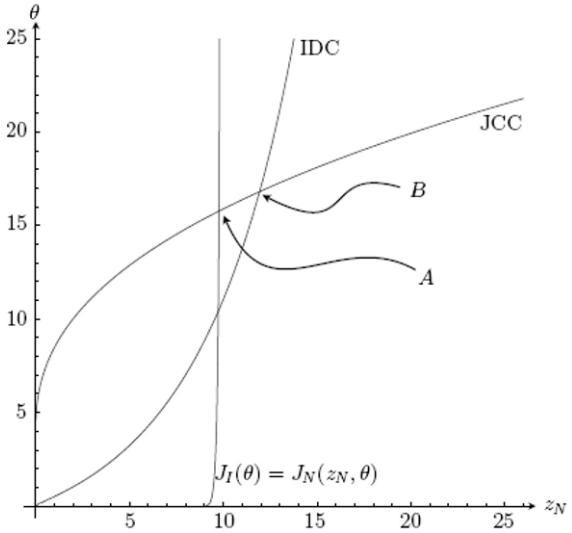
.

22 For the derivation of the slope of the JCC and IDC, please consult the appendix.

23 To simplify the exposition of our results we use the following notation to denote partial derivatives: $G_{2,k} \equiv \frac{\delta G_2^E}{\delta k}$.

because $\eta_{U,\mu}\big|_{\mu=0} > 0$. Together with $G^E_{1,z_N}\big|_{\mu=0} > 0$ and $G^E_{1,\theta}\big|_{\mu=0} < 0$ we find that first time immigration leads to a clockwise rotation of the JCC at its intersection with the curve $J_I(\theta) = J_N(\theta, z_N)$ (see Figure 1).[24]

Figure 1: The IDC and the JCC determining a stable equilibrium



With first time immigration, the human capital endowment of potential migration (or the minimum requirement in terms of human capital for immigration) only matters for the comparative statics. First time immigration will increase (decrease) the labour market tightness θ^E and native human capital z_N^E if the expected present value of a migrant filled job J_I is larger (smaller) than that of a comparable native filled job J_N. Due to a higher exit rate δ_I potential immigrants need more human capital than natives to offset this negative effect. Thus, even if potential immigrants are better educated than native workers $z_I > z_N$ the job value of natives can be higher $J_I < J_N$ and both θ^E and z_N^E decrease. To increase the labour market tightness θ^E and native human capital z_N^E immigration policy has to aim at immigrants who

24 The curve implicitly defined by $J_I(\theta, z_I) = J_N(\theta, z_N)$ is positively sloped in the (z_N, θ)-space originating from $\tilde{z}_N$ which is the solution to $J_I(0, z_I) = J_N(0, \tilde{z}_N)$. For $\theta \to \infty$ we get $z_N \to z_I$.

are very well educated compared to natives. The native wage rate w_N is positively correlated with θ and z_N such that immigration policy directly influences native labour income. The same is true for native employment which will increase if $J_I > J_N$. The effect on total unemployment $u_I + u_N$ is ambiguous if immigration is high skilled ($J_I > J_N$) because the decrease of native unemployment is counteracted by an increasing number of unemployed immigrants. First time immigration is rather unlikely, because today most industrialised countries experience sustained immigration and try to implement a specific immigration policy given a certain history of migration $\{z_I, \mu\}$. A change of the immigration policy can be either a change in the number of immigrants by changing the inflow $d\mu$ or a change of the human capital standards dz_I. We start by assuming that the equilibrium human capital of natives z_N is large enough such that $J_I < J_N$ holds. Either changing the amount of the existing quality of immigration $(d\mu < 0)$, $(d\mu > 0)$ or changing the future quality of immigration $(dz_I < 0), (dz_I > 0)$ leads to the following change of the equilibrium values z_N^E, θ. We first consider the case of more low skilled immigrants as well as decreasing human capital standards for immigrants. The results can be easily derived from the comparative static characteristics of the JCC:

$$G_{1\mu}^E = \frac{d\eta_U}{d\mu}(J_I - J_N) < 0, \; J_I < J_N, \tag{19}$$

$$G_{1z_I}^E = \eta_U(\theta)\frac{q(\theta)(1-\beta)f'(z_I)}{\varrho + \delta_I + s + \beta p(\theta)} > 0. \tag{20}$$

Thus, we derive the same result as with first time immigration, that both increased unskilled immigration and decreasing human capital standards will reduce equilibrium labour market tightness $(\frac{d\theta^E}{d\mu}, \frac{dz_N^E}{d\mu} > 0)$ and human capital investments $(\frac{d\theta^E}{dz_I}, \frac{dz_N^E}{dz_I} > 0)$. This is because the expected present value of a filled job is reduced with a lower educational attainment of immigrants or an increased number of unskilled immigrants. Therefore, offering a vacancy is less attractive for firms, which reduces the number of vacancies and consequently the labour market tightness.[25] Next, we assume that the existing immigration is sufficiently high skilled such that J_I

25 See Lewis (2003) for estimates on the possible impact of immigration on the labour demand of firms.

$>J_N$ holds. In this situation, a change of the migration policy will result in the following change of the equilibrium values:

$$G^E_{1\mu} = \frac{d\eta U}{d\mu}(J_I - J_N) > 0 \quad , J_I > J_N \tag{21}$$

$$G^E_{1z_I} = \eta U(\theta)\frac{q(\theta)(1-\beta)f'(z_I)}{\varrho + \delta_I + s + \beta p(\theta)} > 0 \cdot \tag{22}$$

We get the result, that an increased number and higher quality of migrants will increase the labour market tightness ($\frac{d\theta^E}{d\mu}, \frac{dz^E_N}{d\mu} > 0$) and the human capital acquisition of natives ($\frac{d\theta^E}{dz_I}, \frac{dz^E_N}{dz_I} > 0$).

We may now summarise our findings in:

Proposition 1. In the stable equilibrium, if $J_I < J_N$ an increase in the endowment of human capital of immigrants z^E_I increases θ^E and z^E_N and an increase in the flow of immigrants μ decreases θ^E and z^E_N. If $J_I > J_N$ an increase in the endowment of human capital of immigrants z^E_I and an increased inflow of immigrants μ increases θ^E and z^E_N.

Our result shows that in the context of search frictions, higher minimum requirements of human capital for immigrants leads to skill upgrading of native workers, because this immigration increases the firms' incentive to supply jobs for workers in the host country. This contrasts with much of the literature which mostly focuses on competitive labour markets. In these models high skilled immigration reduces the incentive to invest into education (Fuest et al 2001). However, considering different labour market institutions, by e.g., employing a search theoretic framework reveals totally different implications for immigration policies.

4 Conclusions

We introduce immigration into a search model of equilibrium unemployment and human capital investment of natives. Because of a positive probability of returning to their home countries, immigrants have a higher unemployment rate and earn lower wages per unit human capital compared to natives. We can show theoretically

that an immigration policy which is concerned about the human capital endowment of immigrants and/or the number of immigrants has a decisive impact on the educational decision of natives. An immigration policy which favours higher skilled immigrants will increase the wage rate for the group of high-skilled workers because firms have incentives to increase the number of vacancies. This induces natives to invest more in education.

At this point our analysis is entirely positive and because it lacks any welfare analysis whether or not a specific policy will render welfare gains has to be addressed in future research.

5. Appendix

5.A Derivation of the Wage Setting Equation (10)

Maximisation of the Nash Product (9) yields

$$w_i = \beta f(z_i) + (1-\beta)(\delta_i + \varrho)U_i \quad i = I, N. \tag{23}$$

Substitution of (23) in (6) gives:

$$W_i = \frac{\beta f(z_i) + ((1-\beta)(\varrho + \delta_i) + s)U_i}{\varrho + \delta_i + s} \quad i = I, N. \tag{24}$$

Substitution of (24) in (5) we end up with reservation wage:

$$(\varrho + \delta_i)U_i = \frac{b(\varrho + \delta_i + s) + p(\theta)\beta f(z_i)}{\varrho + \delta_i + s + p(\theta)\beta} \quad i = I, N. \tag{25}$$

Substitution of the reservation wage in (23) yields the wage setting equation (10).

5.B Existence of the Equilibrium

Proof. It is to show that the equilibrium $\left\{z_N^E, \theta^E, u^E\right\}$ exists. The functions $G_1^E(\theta, z_N)$ and $G_2^E(\theta, z_N)$ are continuous and $G_{i,z_N}^E \neq 0 \quad i = 1,2$ on the open interval $(0,\infty)$. Therefore, we can apply the implicit function theorem and express z_N as a function of θ denoted by: $z_{1N}(\theta)$, $z_{2N}(\theta)$,. Because $lim_{\theta \to 0} lim_{z_N \to 0} G_1^E(\theta, z_N) = \infty > k$ the domain of $z_{1N}(\theta)$ is the open interval $(\overline{\theta}_1, \infty)$ with $\overline{\theta}_1 > 0$ and the domain of $z_{2N}(\theta)$ is the open interval $(0,\infty)$. Analysing these functions at their respective domain limits reveals: $lim_{\theta \to \overline{\theta}_1} z_{1N}(\theta) = 0$ and $lim_{\theta \to \infty} z_{1N}(\theta) = \infty$. Given that $lim_{\theta \to \infty} p(\theta) = \infty$, we get $lim_{\theta \to \infty} z_{2N}(\theta) = \overline{z}_2$ where $\overline{z}_2$ is defined by: $\overline{z}_2 := \left\{z_2 : f'(z_2) = (\rho + \delta_N)c\right\}$. At the lower boundary we get $lim_{\theta \to 0} z_{2N}(\theta) = 0$. Next we define the function $\Gamma(\theta) = z_{2N}(\theta) - z_{1N}(\theta)$. Using the previous results we get $lim_{\theta \to \overline{\theta}_1} \Gamma(\theta) > 0$ because $z_{2N}(\theta)$ is strictly increasing. Furthermore we get $lim_{\theta \to \infty} \Gamma(\theta) = -\infty$. Thus, the intermediate value theorem guarantees at least one θ' such that $\Gamma(\theta') = 0$. This concludes the proof that at least one equilibrium exists.

5.C Slope of the IDC and JCC

Differentiation of $G_1^E(\theta, z_N)$ and $G_2^E(\theta, z_N)$ with respect to θ and z_N gives:

$$G_{1,\theta}^E = \frac{dq(\theta)\eta_U}{d\theta} J_I + \frac{dq(\theta)(1-\eta_U)}{d\theta} J_N + q(\theta)\eta_U J_{I,\theta} + q(\theta)(1-\eta_U) J_{N,\theta} < 0, \tag{26}$$

$$G_{1,z_N}^E = q(\theta)(1-\eta_U(\theta)) J_{N,z_N} > 0, \tag{27}$$

$$G_{2,\theta}^E = \frac{\beta p'(\theta)(\varrho + \delta_N + s)}{(\varrho + \delta_N)(\varrho + \delta_N + s + \beta p(\theta))^2} f'(z_N) > 0, \tag{28}$$

$$G_{2,z_N}^E = \frac{\beta p(\theta)}{(\varrho + \delta_N)(\varrho + \delta_N + s + \beta p(\theta))} f''(z_N) < 0, \tag{29}$$

The slope of the JCC and the IDC can then be calculated as:

$$\left.\frac{d\theta}{dz_N}\right|_{G_1^E(\cdot)=k} > 0, \quad \left.\frac{d\theta}{dz_N}\right|_{G_2^E(\cdot)=c} > 0.$$

5.D Proof Proposition 1

Proof. We are in a stable equilibrium: $G_{1\theta}^E G_{2z_N}^E - G_{2\theta}^E G_{1z_N}^E > 0$:

$$\frac{d\theta^E}{d\mu} = -\frac{G_{1\mu}^E G_{2z_N}^E}{G_{1\theta}^E G_{2z_N}^E - G_{2\theta}^E G_{1z_N}^E} \begin{cases} > 0 & \text{if} \quad (J_I - J_N) > 0 \\ < 0 & \text{if} \quad (J_I - J_N) < 0 \end{cases},$$

$$\frac{dz_N^E}{d\mu} = -\frac{-G_{2\theta}^E G_{1\mu}^E}{G_{1\theta}^E G_{2z_N}^E - G_{2\theta}^E G_{1z_N}^E} \begin{cases} > 0 & \text{if} \quad (J_I - J_N) > 0 \\ < 0 & \text{if} \quad (J_I - J_N) < 0 \end{cases}.$$

$$\frac{d\theta^E}{dz_1} = -\frac{G_{1z_1}^E G_{2z_N}^E}{G_{1\theta}^E G_{2z_N}^E - G_{2\theta}^E G_{1z_N}^E} > 0,$$

$$\frac{dz_N^E}{dz_1} = -\frac{-G_{2\theta}^E G_{1z_I}^E}{G_{1\theta}^E G_{2z_N}^E - G_{2\theta}^E G_{1z_N}^E} > 0.$$

The number of unemployed workers changes as follows:

$$du = \left.\frac{\partial u}{\partial \theta}\right|_{\mu=0} d\theta + \left.\frac{\partial u}{\partial \mu}\right|_{\mu=0} d\mu,$$

$$du = -\frac{(s+\delta_N)p'(\theta)}{(s+\delta_N+p(\theta))^2} d\theta + \frac{1}{\delta_I}\frac{(s+\delta_I)}{(s+\delta_I+p(\theta))} d\mu.$$

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V. Issues in Female Labour Supply

The Non-EU-25 Female Population in Spain: A Factor Analysis of Labour Market Integration at Regional Level[1]

Elena Vidal Coso, Fernando Gil Alonso, Andreu Domingo i Valls

1. Introduction: Female Immigrant Labour Force in a Complementarity Context

During the last decade, Spain has experienced an important growth in its volume of immigrants from outside the EU-25. Although that flow of immigrants shares common characteristics with others arriving in the Southern EU (Baldwin-Edwards et al 1999, King et al. 2000, Ribas-Mateos 2004, Domingo et al. forthcoming), it must be situated in the context of globalisation of capital and labour markets (Baldwin-Edwards 1997, Arango 2003, Castles et al. 2003, Balch 2005).

Those recent flows have been interpreted as "demographic replacement or substitution migration" where an immigrant population is substituting the autochthonous population, which is decreasing, alleviating the negative effects of population ageing, especially the possible decrease of labour force (United Nations 2001, European Commission 2002). Although this approach has been criticised (Coleman et al. 2004) and authors demonstrated that the approach is not correct, in Spain neither in other countries of the EU (Vidal et al. 2006), the arrival of international migration is still interpreted as a replacement of labour vacancies caused by ageing populations in host countries.

Despite this "demographic replacement" discourse, the massive arrival of immigrants to Spain - more than a consequence of recent demographic evolution or any shortages in the labour force product of consecutive decreasing generations - is a product of the development of a dual labour market (Cachón 1997, Carrasco 2003) where immigrants hold those positions that native workers try to avoid (due to the massive educational improvement). The theoretical framework which explains the mechanisms of a dual labour market and of complementarity between

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immigrant and autochthonous workers is not a new one: the Piore's dual market theory was developed long ago (Piore 1979) and labour segmentation processes had been analysed in other countries (Dickens et al. 1988, Enchautegui 1998). The intensity and temporal concentration of immigration flows in Spain and in general to all Southern EU countries make it interesting to study labour segmentation in those countries (Martínez Veiga 1999, Vitale 2000, Parella 2003, Solé et al. 2003, Garrido et al. 2004). Previous studies about Western Europe by Jennissen (2003) and about Spain (Domingo 2002, Carrasco et al. 2004) have already identified the labour demand caused by the general educational improvement of the autochthonous population, specially of the female population, as the main reason for the massive arrival of international migration. Therefore, in our opinion, more than any "substitution" of native workers by foreigners the analysis of the data shows processes of "complementarity" between native and foreign workers, where arrival of immigrants (more of them women) is directly related to a process of social and labour promotion of the native population, specially of native women (Domingo et al. 2004 and 2005, Vidal et al. 2006, Gil et al. 2006a).

The need to fill the bottom positions of the labour market is the product of labour ascension of the native population and of the emergence of new activities related to the externalisation of domestic reproduction (specially childcare and old people's care or cleaning) in a context of growing female labour participation and population ageing. These elements are more decisive in order to explain the arrival of new non-EU immigrants - especially immigrant women - to Spain than any shortage of labour force caused by a fertility decline. Other non-demographic factors, as the intense development of precarious industry sectors, with low salaries and weak regularisation as "personal services", "tourist sector", "intensive agriculture" and "building industry" are also important to explain the growing immigration (Gil et al. 2006a). Obviously, those industries are not equally distributed within the national territory, implying different demand of immigrant labour force, depending on the region. In consequence, the presence of working immigrants but also inactive immigrants will differ enormously depending on the socio-demographic and economic characteristics of the region of destination within Spain.

In previous studies we analysed complementary processes in Spain by industry sector (Gil et al 2006a), the complementarity between Spanish people and Latin-Americans (Domingo 2005, Domingo et al. 2006, Gil et al. 2006b)and we compared the situation in Spain with those for other Mediterranean countries (Domingo et al. forthcoming) or for the EU-15 countries (Vidal et al. 2006). In this paper we will focus on the regional distribution of the non-EU population, trying to identify some explanatory factors of this distribution. We exclude the foreign EU population of the analysis, as they have socio-demographic and labour characteristics different from those of the rest of the foreign population. Within the complementarity theoretical framework, this paper focuses on the female population, as female immigra-

tion demand in the Spanish labour market is directly related to educational, labour and social improvement of the young female generations in Spain (Garrido 1992, Pérez 2001). This upward labour and social mobility of young women has generated new labour demands: Positions that young Spanish women are not going to hold anymore and also new vacancies in domestic services have to be filled, which are caused by the increased female participation in the labour market.

Although complementarity or labour promotion of Spanish workers due to immigrants' labour insertion holds for male and female workers, jobs between male and female workers differ, following a clear gender pattern. Effectively, immigrant labour demand is mainly the product of the externalisation of domestic tasks, which were historically taken by autochthonous women as a part of the reproductive work that was assigned to them in the division of gender roles. Despite of this, not all immigrant women are holding jobs in domestic services and some men also may be found in these labour positions. However, what is true is that a great share of foreign women in Spain insert themselves in the labour market through domestic services and that their social image is derived from this position in the labour market, identifying some nationalities with that kind of work, specially in the case of the Latin-Americans and Filipino women. In this sense, Spain follows the general pattern of increasing female international migration in the last decades of the 20th century (Castels et al. 2003). What makes Spain an exception of this general pattern is the speed and intensity of the phenomena.

The gender variable is crucial to understand the specific model of international migration of the Southern EU (King et al. 2000) which must be set in context of capitalism development and socio-demographic characteristics of these countries. Mingione (1995) identifies a distinctive capitalism model for Southern countries characterised by labour instability, a rapid and general improvement of educational levels for younger generations, especially for women and an intense growth of levels of female labour participation due to the increase of female labour demand in the services sector. This massive incorporation of women to the labour market has not been compensated by any balance of responsibilities in domestic tasks within couples' households. Because there has been an absence of any effective familial-political measure in Southern countries to allow women to conciliate work and family (Parella 2000) and due to deficiencies in the offer of public assistance services the easiest and cheapest solution for many families have been to contract those services, especially child and old people's care, in the private market, mainly through non-EU female labour force. King and Zontini (2000) identify other common occupations of immigrant women: in hotels and restaurants (as waitresses, charwomen or kitchen helpers), as assistants in care institutions, trade assistants, etc.. Some authors stress the existence of a common trend in all those different occupations: all may be identified as traditionally female jobs, especially in Catholic societies in Southern Europe: cleaning, assisting, taking care of children or old peo-

ple, etc. are jobs which young native women avoid. Furthermore, immigrant women suffer a triple discrimination: class, gender and ethnic group discrimination (Solé 2001).

In this context, far from the traditional model in which female migration was identified as family reunification migration, posterior to their husbands' or parents' previous migrations, new female migration must be understood as a personal project of a woman, an answer to a specific labour demand. It is necessary to emphasise, however, the diverse situation of immigrant women regarding to labour market: On the one hand we have the Latin-American immigrants, with high activity rates who lead the migration flows from their countries to Spain. On the other hand, we find African immigrants with low labour market participation who enter the country mainly as reunification migrants and are occupied with the reproductive tasks inside households.

Within this theoretical framework the gender perspective plays a central role in the immigration analysis, so this paper has two aims. Firstly, in order to answer our hypothesis that the arrival of immigrants is more determined by socio-demographic characteristics of the host country and its labour market's dynamics than by the immigrants' characteristics, we grouped in a factor analysis some different regional variables in few components. Our intention is to create new components that relate regional characteristics of the labour market participation of non-EU women with the demographic structure and labour market trends of special regions and with the education and labour market characteristics of autochthonous women in special regions.

Secondly, once created those explicative factors, our next objective is the construction of a statistically significant model to help us to explain the regional distribution of non-EU women, using factors as explanatory variables. Since the percentage of non-EU women differ within the Spanish territory, our initial hypothesis is that the percentage of non-EU women differs between regions in the function of their possibilities to insert in the regional labour market. Using multiple lineal regression we use factors as explanatory variables to demonstrate that the presence of foreign women is more related to some socio-demographic and regional labour characteristics than to others.

The following section focuses on the data set used in the analysis, the Spanish Labour Force Survey. The third section develops the methodology and results of the factor analysis and the fourth section is dedicated to the explanatory model. Finally, in the fifth section the main conclusions are summarised.

2. Data Source: The Spanish Labour Force Survey (LFS)

In this investigation we use the 2006 (second quarter) Spanish Labour Force Survey. This survey interviews approximately 200,000 persons in 65,000 households and is representative for the working age population in Spain. The survey contains a great variety of variables at individual level about socio-demographic and labour characteristics of the population, as sex, age, employment status, employment characteristics of the main job, labour status, previous work experience, search for employment, etc. (Amuedo 2000), that makes its analysis the best option for the purpose. Although the Spanish Labour Force Survey intents to be representative for the whole Spanish population aged 16 years and over, the poor cover of foreigners of the survey (Cachón 2004) and the unequal representivity of foreigners depending on their origins must be highlighted: Africans and EU-foreigners are more underrepresented than people from other origins. The Spanish LFS is modified in 2005 in order to adapt to the new demographic and labour market developments, especially due to the rapid and recent growth of residing foreigners in Spain. One of the most significant changes was the substitution of the sampling frame based on the 1991 Census by the new sampling frame based on the 2001 Census and successive population revisions (García 2005). The most important consequence of this change is that new weight factors were applied to the sample and are more coincident with the recent volume of the population, the recent age and sex structure in every region and the recent volume of population by nationality. Obviously, the updates in the sample frame have special importance in order to calculate percentages of the foreign population, since the foreign population in Spain has grown significantly between 1999 and 2001 (INE 2005).

3. Factor Analysis

3.1 Methodology

In the creation of the explanative model we chose a set of variables at regional level relating to the regional socio-demographic and labour market characteristics and relating to the labour characteristics of the autochthonous population and to labour characteristics of foreign women residing in the region. Previous exploratory analyses of data revealed the existence of a correlation between some groups of our fourteen original variables. Using the mathematical technique of Principal Components Factor Analysis, we transformed "latent structures" or a group of correlated variables in four independent factors. This reduction of data makes it easier to describe all original variables with a minimum loss of information and the creation of our multiple explanatory model as we reduced our fourteen original explanatory

variables to four explanatory factors, eliminating at the same time, multicollinearity problems between explanative variables (Field 2000, Solsona 1991).

Mathematically, factor analysis starts from a two dimensions matrix (regions by regional characteristics) and constructs the lineal combinations that best explain the information contained in this matrix. Resulting factors are linear combinations of original variables and have high coefficients for those variables with high influence in the factor and small coefficients in other variables, those with poor influence on the factor. The first factor extracted is the one that explains the information of the original variables best. Calculation continues until all original variance is explained, with the construction of as many factors as original variables, although every time another factor is created, the additional variance decreases. There is no unique criterion to decide how many factors should be obtained. In our analysis it was decided to reduce our original variables to four factors after considering the percentage of explained variance (72%) and the substantive explanatory power of the factors. The first factor explains 30.6% of the variance, the second explains 22%, the third 10.3% and the fourth 9.2%.

Our original variables chosen (at regional level) from which we have extracted four explanatory factors are:

A. Regional demographic characteristics:
    1. Percentage of population aged 65 and over
    2. Percentage of population aged 16 to 30
B. Regional labour market characteristics:
    3. Percentage of the autochthonous population in the primary sector (agriculture, etc.)
    4. Percentage of the autochthonous population in the industrial sector
    5. Percentage of the autochthonous population in the services sector
    6. Percentage that non-EU active women represents over total female activity (women aged 16 to 64)
C. Educational and labour characteristics of Spanish women residing in the region:
    7. Spanish women activity rates (aged 16 to 64)
    8. Percentage of Spanish women with university degree (women aged 25 to 44)
    9. Percentage of Spanish women, non-qualified or in elementary occupations
    10. Percentage of female Spanish directives, managers, professionals and technicians
D. Labour characteristics of non-EU women residing in the region:
    11. Activity rates of non-EU women (aged 16 to 64)

12. Percentage of non-EU women employed in unskilled occupations in agriculture
13. Percentage of non-EU women employed in hotels and restaurants
14. Percentage of non-EU women employed in domestic services

Resulting factors were rotated using the Varimax system, maximising scores of variables for some of the factors and minimising scores of the same variables for the rest of the factors. Varimax rotation makes clearer which variable is related to which factor, facilitating interpretations.

3.2 Factor Analysis Results

Obtaining our four factors must not be interpreted as the principal aim of our analysis. We grouped our original variables in four independent factors to avoid multicollinearity problems in our explanatory model. However, the analysis of correlation between factors and variables (Table 1) and the analysis of factorial scores for every region (Table 2) allow us to understand the explanatory power of the resulting factors and how they are observable in the territory.

Table 1 shows which variables are more or less correlated with every factor. Following our initial hypothesis about complementarity, the *first factor* has high scores in those regions with the existence of high percentages of women with university degree and high activity rates, high percentages of women employed in skilled occupations and a high presence of native population in the industrial sector. On contrast, this factor is negatively correlated with high percentages of the young population, with high percentages of native and non-EU women employed in the primary sector and high percentages of women employed in elementary occupations. In Table 2 we can observe that regions with high scores in *Factor 1* are in the Northeast of Spain, including more industrialised and urban regions (Basque Country, Navarra, Madrid and Catalonia). On contrast, Southern regions and some markedly rural regions in the North have low scores in this factor, especially Huelva, Badajoz, Zamora and Almería (Figure 1).

The *second factor* is mainly affected by those variables that show an ageing and rural population, where the primary sector employs high percentages of the native population and the services sector is still less developed and where non-EU women are employed in hotels and restaurants. The cartographic representation shows that interior regions present higher scores for this factor, especially high ageing regions situated in the North of the territory (Figure 2): Zamora, Lugo, Soria and Palencia. In contrast, regions with low punctuation in *Factor 2* are, Tenerife, Huelva, Las Palmas and Álava, with a younger age structure and a larger share of the active

population in the services sector. In other words, all are Mediterranean regions, Balearic and Canary Islands and Southern regions (with the exception of Jaén).

Table 1: Correlations between original variables and resulting factors (regional level data)

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Percentage of non-qualified Spanish women or in elementary occupations	-0.86378			
Percentage of Spanish women with university educational levels (aged 25 to 44)	0.82951			
Spanish women activity rates (aged 15 to 65)	0.76496			
Percentage of directives, managers, professionals and technical Spanish women	0.70043			
Percentage of non-EU women in unskilled occupations in agriculture	-0.64829			
Percentage of Spanish population aged 65 and over		0.89876		
Percentage of Spanish population aged 16 to 30	-0.50827	-0.74202		
Percentage of non-EU women employed in Hotels and restaurants		0.67473		
Percentage of autochthonous population in primary sector	-0.58663	-0.66718		
Percentage of autochthonous population in service sector		-0.52267	0.77209	
Activity rates of non-EU women (aged 16 to 64)			0.62295	
Percentage of autochthonous population in industrial sector	0.60319		-0.62287	
Percentage of non-EU population employed in domestic services				-0.77309
Percentage that non-EU active women represents over total female activity (aged 16 to 65)				0.70705

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

The *third factor* is highly related to high percentages of the native population employed in the services sector, with a small presence in the industry sector and with high foreign women's activity rates. In the cartographic representation of regional scores for *Factor 3* it is not possible to distinguish any regional pattern as clear as for

the previous factors. However, we highlight high scores in Balearic Islands, Canary Islands and Madrid, with highly services-based economies.

Finally, the *fourth factor* is only clearly related to two variables: negatively related to the percentage of non-EU employed in domestic services and positively with the percentage of non-EU female activity over total female activity. The map of *Factor 4* shows higher scores in Mediterranean regions, on the Balearic Islands, Canary Islands, the North and the centre of the territory, whereas low scores are found for Western, more rural regions.

From these results we can conclude that there are some interesting relations between labour characteristics of non-EU women and labour characteristics of Spanish women and that these relations differ from region to region. *Factor 1*, for example, explains most of the variance and has high scores in more industrialised regions, with a higher presence of women with a university degree and with higher female activity rates as well as low scores in those regions with low percentages of non-EU women working in the primary sector. *Factor 2* obtained high scores in those regions with a high percentage of rural and ageing population with high levels of non-EU women employed in hotels and restaurants (curiously, there is no correlation of this factor with a higher presence of non-EU women employed in domestic services, perhaps because in these rural and more traditional regions domestic tasks are still mainly done in the familial sphere). The highest activity rates of non-EU women are positively related to a high presence of the services sector (*Factor 3*): administrative or directive services (Madrid) or tourist services (Balearics and Canary Islands). Finally, *Factor 4* shows an inverse relation between high proportions that non-EU active women represent over total active women and female immigrants' participation in domestic services. High scores for this factor may be found in some interior regions but especially in Mediterranean regions. We interpret that in the way that the existence of a more diverse economy allows migrant women to choose between different labour opportunities, other than domestic services.

Summarising, *Factor 1* is related to rich and more developed regions, *Factor 2* to a rural and highly ageing population, *Factor 3* to regions with more importance of the services sector and *Factor 4* to those regions with a high proportion of non-EU active women and with a greater diverse economy. We will see in the next section that in regions with high positive scores in *Factors 1* or *3* or 4 (and negative scores in *Factor 2*) the percentage of non-EU women of working age will be higher than in those regions whose scores are inversely.

Table 2: Regional scores of the four extracted factors

	Factor 1	Factor 2	Factor 3	Factor 4
Alava	1.685	-1.286	-1.832	-0.922
Albacete	-0.698	-0.727	-0.776	-0.238
Alacant	-0.054	-0.912	-0.228	1.068
Almería	-1.482	-0.276	1.405	2.620
Ávila	-0.346	0.758	0.109	-1.331
Badajoz	-1.799	-0.615	-0.817	-1.318
Illes Balears	0.521	-0.729	1.882	0.565
Barcelona	1.282	-0.377	-0.287	0.792
Burgos	0.833	1.132	-1.658	1.933
Cáceres	-0.627	0.207	0.325	-1.401
Cádiz	-1.283	-0.981	0.869	-0.331
Castelló	1.030	-0.121	-0.397	0.800
Ciudad Real	-0.343	-0.144	-0.458	0.119
Córdoba	-0.901	-0.111	0.276	-0.928
A Coruña	0.505	0.256	0.853	-0.029
Cuenca	-1.272	1.210	-1.530	0.276
Girona	1.196	-0.764	-0.474	0.992
Granada	-1.096	0.164	1.175	0.537
Guadalajara	0.180	0.119	0.023	1.058
Guipúzcoa	1.467	-0.065	0.426	-0.079
Huelva	-2.902	-1.436	-2.520	0.496
Huesca	-0.082	1.156	0.758	-0.546
Jaén	-1.281	0.457	0.081	-0.528
León	-0.111	0.522	0.779	-1.419
Lleida	0.552	0.319	-0.579	0.108
La Rioja	0.761	-0.116	-0.585	0.603
Lugo	-0.269	2.401	-0.163	-0.028
Madrid	1.631	-0.647	2.180	0.255
Málaga	-0.903	-1.207	0.734	0.685
Murcia	-0.710	-1.267	-0.891	1.120
Navarra	1.580	-0.214	-0.461	0.336
Ourense	0.286	0.401	-0.327	-2.792
Asturias	0.261	0.923	-0.105	-0.147
Palencia	0.148	1.578	-0.436	0.432
Las Palmas	-0.908	-1.288	2.305	0.575
Pontevedra	0.040	-0.477	-1.511	-1.276

	Factor 1	Factor 2	Factor 3	Factor 4
Salamanca	0.132	0.420	1.089	-1.806
Santa Cruz de Tenerife	-0.169	-1.474	0.392	-0.485
Cantabria	0.095	-0.119	0.357	-0.479
Segovia	0.241	1.221	0.913	0.988
Sevilla	-0.590	-0.876	0.830	-1.021
Soria	0.861	2.003	-0.330	0.732
Tarragona	0.577	-0.247	-0.113	0.888
Teruel	0.480	1.265	-1.383	-0.240
Toledo	-0.362	-0.302	-0.988	0.709
València	0.607	-0.671	0.097	0.572
Valladolid	0.463	-1.082	-0.429	-0.172
Vizcaya	1.540	-0.574	0.229	-1.484
Zamora	-1.635	2.942	1.043	0.388
Zaragoza	0.869	-0.352	0.149	-0.643

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

Figure 1: Regional scores for Factor 1

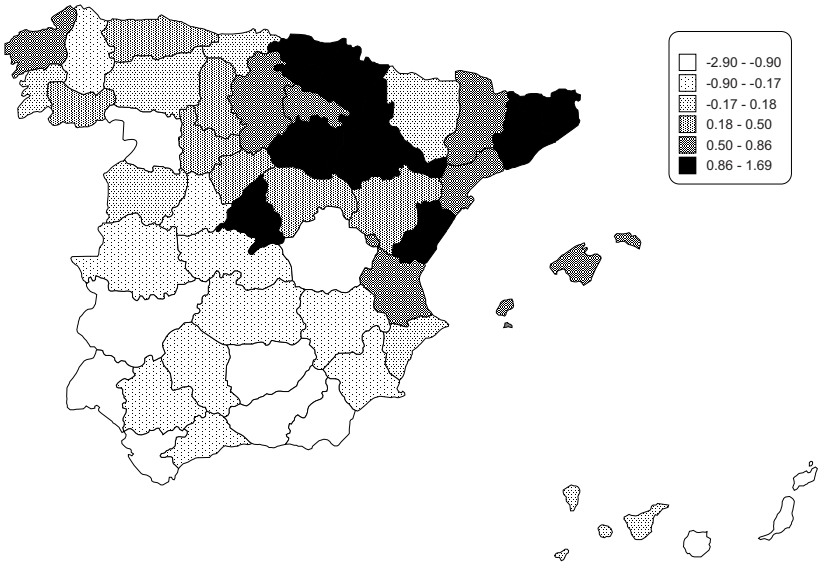


Figure 2: Regional scores for Factor 2

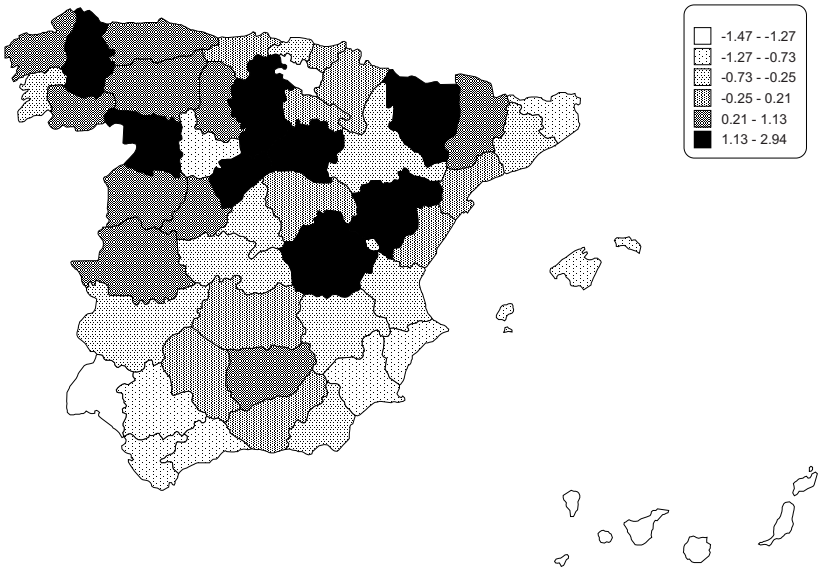


Figure 3: Regional scores for Factor 3

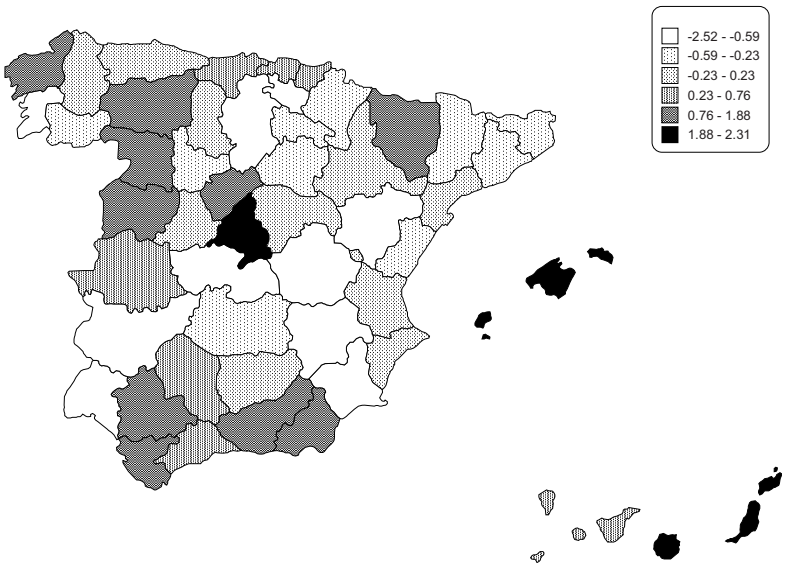
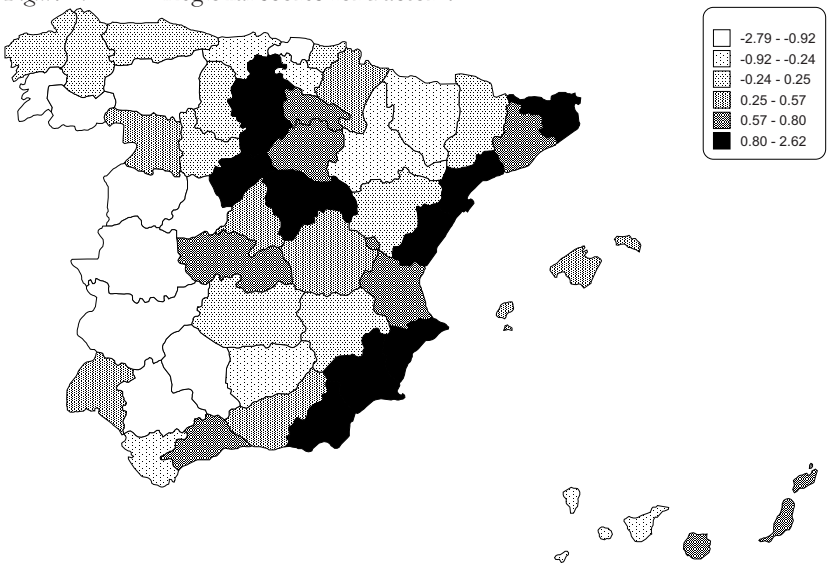


Figure 4: Regional scores for Factor 4



Data source: 2006 (2n quarter) Spanish Labour Force Survey.

4. Multiple Linear Regression

4.1 Methodology

As we explained in the introduction section, once our original explanatory variables have been reduced to four independent factors, our next objective is to predict for every region *the proportion of non-EU women aged 16 to 64 represented over total women aged 16 to 64* using our four independent factors as explanatory variables. Since our dependent variable is a continuous variable, the appropriate statistical technique is the multiple linear regression. We assume that the dependent variable y is directly related to a linear combination of p variables x. This linear relation is represented in the equation:

$$Y_i = \beta_0 + \beta_{1\ x}1_i + \beta_{2x}2_i + \ldots + \beta_{px}pi + e_i$$

Where β_0 is the constant or origin when all explanatory variables are equal to 0, β_1 to β_p are the coefficients of p explanatory variables or the scope of the line and e_i is the residual not explained by the model.

4.2 Results

The results of the analysis show that our model, once the four factors have been included as explanatory variables, explains 65% (R square) of the variance of the dependent variable (Table 3) and the analysis *anova* (Sig.=0,000) indicates that our model is significant (Table 4). Finally, Table 5 shows coefficients and signification of the constant and the four explanatory factors, all of them statistically significant. From these coefficients (β) we can obtain the *predicted proportions of non-EU women aged 16 to 64 represented over total women aged 16 to 64* and the residual or part of the variance not explained by the model. The resulting equation is:

% non-EU women (16-64) = 0,083 + 0,015***Factor 1* – 0,012***Factor 2* + 0,012***Factor 3* + 0,038** Factor 4* + residual.

From the equation we get that every increase in one unit in the scores for *Factor 1* represents an increase of 0.015 in the predicted *proportions that non-EU women aged 16 to 64 represent over total women aged 16 to 64*. In contrast, an increase of one unit in the score for *Factor 2* represents a decrease of –0.012 in the proportion. Every unit that increases the regional scores for *Factor 3* and *Factor 4* represents an increase in the predicted proportion of 0.012 and 0.038, respectively.

Table 3: Summary of the multiple linear regression model

Model Summary			
R	0.809	Variables:	Constant
R square	0.655		REGR factor score 1 for analysis 1
Corrected R square	0.624		REGR factor score 2 for analysis 1
Standard Error	0.033		REGR factor score 3 for analysis 1
	1.951		REGR factor score 4 for analysis 1

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

Table 4: Anova analysis

ANOVA(b)						
Model		Sum of Squares	gl	Mean Square	F	Sig.
1	Regression	0.095	4.000	0.024	21.335	0
	Residual	0.050	45.000	0.001		
	Total	0.145	49.000			

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

Table 5: Coefficients' signification

Coefficients(a)							
	Unstand. Coefficients		Stand. Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta	Tole-rance	FIV	B	Std. Error
Constant	0.083	0.005		17.47	0.000		
REGR factor score 1 for analysis 1	0.015	0.005	0.273	3.121	0.003	1.000	1.000
REGR factor score 2 for analysis 1	-0.012	0.005	-0.219	-2.502	0.005	1.000	1.000
REGR factor score 3 for analysis 1	0.012	0.005	0.212	2.426	0.004	1.000	1.000
REGR factor score 4 for analysis 1	0.038	0.005	0.698	7.966	0.000	1.000	1.000

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

The goodness of the model could be observed in Figures 5 and 6. Figure 5 represents *the proportions of non-EU women aged 16 to 64 represented over total women aged 16 to 64* obtained from 2006 LFS data. Figure 6 shows proportions predicted by our model. Table 6 contains the regional LFS proportions, regional predicted proportions and regional residuals or information not explained by our model.

From the table and figures we conclude that the results are quite satisfactory. Form LFS percentages we conclude that larger proportions of non-EU women aged 16 to 64 are in Mediterranean regions, on the Balearic Islands, Canary Islands, in Northern regions and in Madrid and surrounding regions. Lower proportions are concentrated in Western regions, North-western regions and South-western regions. Predicted values for our model, if they are evidently not the same, are in concordance with values obtained directly from 2006 Spanish LFS data. However, the residuals in Figure 7 indicate that the predicted values are over-emphasised in Northern regions as in A Coruña, Lugo, Asturias, Cantabria and Basque Country regions, in the Mediterranean regions as Barcelona, Valencia and Alicante, in some interior regions as Burgos, Palencia, Valladolid and Zamora and in all regions of Andalusia, with the exception of Almería. On the other hand, the model underemphasises proportions in some regions in the centre of Spain, concretely in Madrid and surrounding regions (Ávila, Segovia, Cuenca, Guadalajara), in La Rioja and Aragón and some Mediterranean regions as Girona, Lleida, Tarragona, Castellón, Murcia and Almería.

In spite of the existence of these residuals, the majority of the predicted values are not far from those calculated directly from the 2006 LFS. This concordance guarantees the goodness of the model and the relevance of these four factors ex-

tracted from the original variables. Concretely, *Factor 4* (related to a high proportion of non-EU female activity over total female activity) is the factor with more explanatory power in our model. We interpret this explanatory power as the fact that recent female migration (contrary to previous feminine reunification movements) has as the main objective the labour incorporation in the host labour markets. The percentages of working-age immigrant women in regions of destination are very similar to the percentages that they represent over the total female labour force. The second factor of importance in the model is *Factor 1*, related to richer and developed regions. In the inverse sense, *Factor 2* (with high scores in rural and ageing regions) is the next factor of explanatory importance. Finally *Factor 3* (related to regions with high percentages of the native population) is also determinant in the model, although with less magnitude. Obviously, when a region, for example Madrid, has high scores for more than one factor, our model will predict high proportions of non-EU women (although in this region the model underestimated the proportion, 14.9% predicted, compared to 16.4% real value). On the contrary, when regions present low scores for *Factors 1*, *3* and *4* (for example, Cáceres, which is a prototype of a rural, ageing and agricultural used region), this means that the predicted values in the model will also be small.

Figure 5: Original Non-EU women (16 to 64) proportion

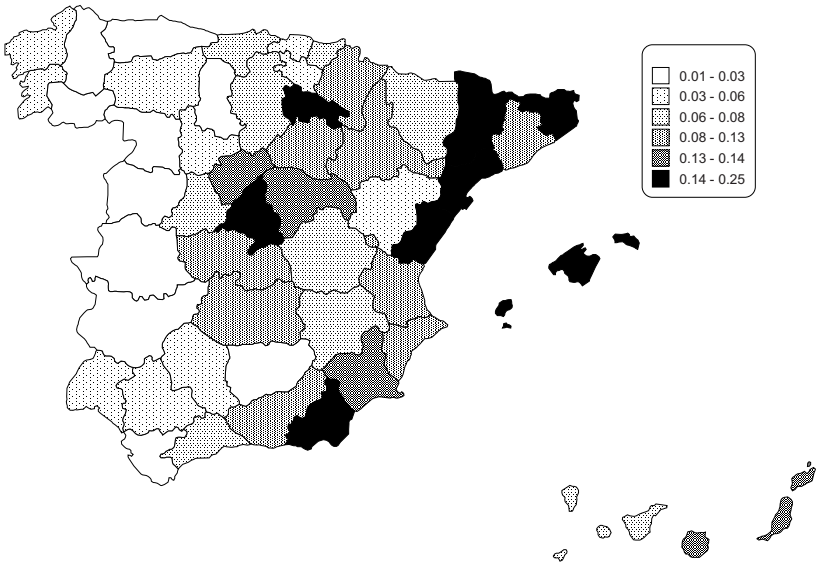


Figure 6: Model predicted Non-EU women (16 to 64) proportions

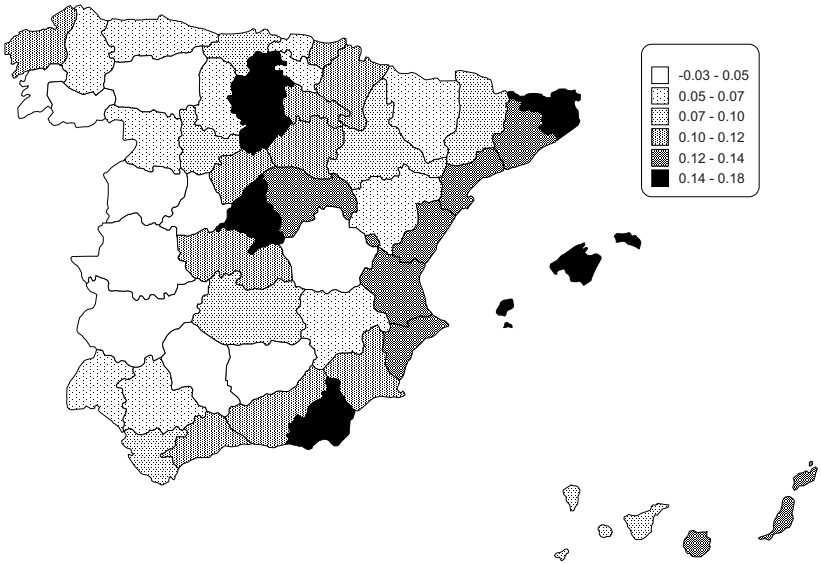
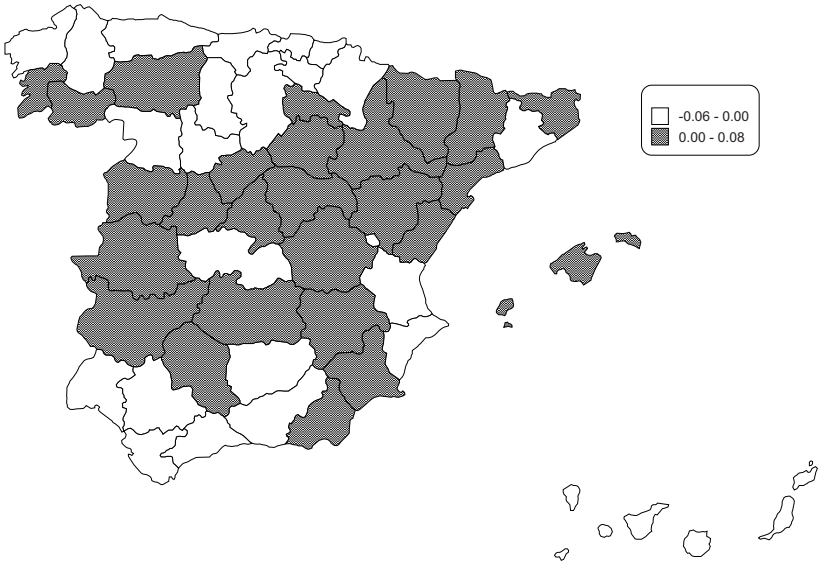


Figure 7: Model's residuals (Original proportions – Predicted proportions)



Data source: 2006 (2n quarter) Spanish Labour Force Survey.

Table 6: Original Non-EU women (16 to 64) regional proportions versus Predicted Non-EU women (16 to 64) regional proportions and model's residuals

	Percentages: LFS	Percentages: Model	Residuals
Alava	3.7%	6.7%	-3.0%
Albacete	7.5%	6.3%	1.2%
Alacant	11.2%	13.1%	-1.9%
Almería	25.4%	18.0%	7.4%
Ávila	8.2%	1.9%	6.3%
Badajoz	2.1%	0.4%	1.7%
Illes Balears	14.5%	14.2%	0.3%
Barcelona	12.4%	13.3%	-0.9%
Burgos	8.1%	13.6%	-5.4%
Cáceres	2.9%	2.1%	0.8%
Cádiz	1.7%	7.3%	-5.6%
Castelló	17.0%	12.5%	4.5%
Ciudad Real	8.4%	7.8%	0.5%
Córdoba	3.8%	3.8%	0.0%
A Coruña	3.8%	9.6%	-5.8%
Cuenca	6.0%	4.2%	1.8%
Girona	18.1%	14.2%	3.9%
Granada	8.8%	9.8%	-1.1%
Guadalajara	13.8%	12.4%	1.4%
Guipúzcoa	6.1%	10.7%	-4.6%
Huelva	3.6%	4.6%	-1.0%
Huesca	8.1%	5.6%	2.6%
Jaén	2.3%	3.9%	-1.6%
León	3.1%	3.0%	0.2%
Lleida	16.3%	8.4%	7.8%
La Rioja	14.1%	11.1%	2.9%
Lugo	2.0%	4.7%	-2.7%
Madrid	16.4%	14.9%	1.5%
Málaga	6.8%	11.8%	-5.0%
Murcia	12.8%	11.9%	0.9%
Navarra	11.0%	11.6%	-0.7%
Ourense	0.9%	-2.8%	3.7%
Asturias	3.1%	6.9%	-3.8%
Palencia	3.0%	7.7%	-4.7%
Las Palmas	12.8%	13.3%	-0.5%
Pontevedra	3.7%	2.3%	1.5%

	Percentages: LFS	Percentages: Model	Residuals
Salamanca	2.4%	2.3%	0.1%
Santa Cruz de Tenerife	8.3%	8.4%	-0.1%
Cantabria	5.9%	7.1%	-1.2%
Segovia	13.9%	12.0%	1.9%
Sevilla	4.3%	5.5%	-1.2%
Soria	9.6%	9.5%	0.1%
Tarragona	16.5%	12.7%	3.8%
Teruel	5.6%	4.9%	0.7%
Toledo	9.2%	9.6%	-0.4%
València	11.5%	12.2%	-0.7%
Valladolid	4.2%	9.1%	-4.9%
Vizcaya	4.3%	5.9%	-1.6%
Zamora	2.7%	5.0%	-2.2%
Zaragoza	10.9%	7.7%	3.2%

Data source: 2006 (2n quarter) Spanish Labour Force Survey.

5. Conclusions

The principal aim of this paper was to analyse the socio-demographic and labour factors that help us to understand the regional distribution of non-EU women aged 16 to 64 in Spain. Our theoretical framework is the complementarity between native and immigrant workers in the host labour market that relates immigrant arrivals with the educational, labour and social promotion of the native population. In this complementary process the labour insertion of immigrant workers depends on Spanish labour market characteristics and on the socio-demographic characteristics of the Spanish population. Following this argument we chose explanatory variables which we believe are related to the regional distribution of non-EU migrants in Spain. Through the statistical method of *principal components factor analysis*, original explanatory variables were grouped in four independent explanatory factors that help us to understand existent relations between original variables and allow to construct an explanatory model avoiding multicollinearity problems. Factors' scores and their cartographic representation help to classify the Spanish territory in relation to immigrant and native demographic and labour characteristics.

The second step in the analysis was the creation of an explanatory model of *proportions that non-EU women aged 16 to 64 represented over total women aged 16 to 64* in every region using the statistical method of multiple linear regression, where the four factors extracted were used as explanatory variables. The model obtained is statically significant and explains 64% of the variance of the dependent variable.

The factor with more explanatory power in the model is *Factor 4*. Since the recent migration of women has the labour incorporation in the host labour markets as the main objective, the percentages of working-age immigrant women in regions of destination would be very similar to the proportion that these women represent in the host labour market (variable highly related to *Factor 4*). Following in importance is *Factor 1*, related to rich and more developed regions. *Factor 2*, related to rural and ageing regions and *Factor 3*, related to younger populations and high levels of the population in services sector. Those regions with high scores for more than one factor will have high proportions of non-EU women. On the contrary, when regions present low scores for *Factors 1*, *3* and *4* their proportions are smaller. In general, the predicted values of our model follow the same territorial pattern as the real values.

In conclusion, the factor analysis and the explanatory model confirm the existence of an association between the arrival of immigrant women from non-EU countries with Spanish regional characteristics related to native female labour force (educational level, occupational category, activity rates, etc.), to the demographic structure (proportions of young or ageing population) and to the labour market trends (industrial distribution). The results are especially significant in regions where new flows of immigrants have been parallel to a process of improvement in the educational levels of native women and to an increase of female activity rates, confirming our initial hypothesis of the existence of a complementarity between both processes.

At this point we want to finalise with some reflections about the evolution in the role of native and immigrant women in the productive and reproductive work. It is well-known that social and demographic recent changes have deeply modified the traditional gender roles of Southern Europe's societies. Young women have massively incorporated to the labour market without a parallel process towards a more equilibrate distribution of domestic tasks within couples and together with the existence of a weak welfare state with an insufficient offer of public social services. In order to achieve the social promotion of Spanish women according to their educational levels, families, when they can afford it, externalised domestic services (cleaning, childcare, elderly care, etc.) by employing foreign women. These women, due to their condition of being women, are successors of the predominant traditional role of Spanish females, which Spanish women try to avoid to play. Furthermore, their presence in the Spanish labour market is mainly reduced to these traditionally female occupations as helpers, cleaners or assistants, independently of their educational level or professional training. Doing so, traditional gender roles are perpetuated, even when the host society believes that they are overcome.

Immigrant women suffer this gender discrimination together with an ethnic or national discrimination that affects women from poor countries, especially African women. Moreover, low activity rates of African women may be interpreted as a

consequence of the Spanish legislation, which hamper the labour insertion of "re-unification migrants". But it can also be seen as a consequence of discrimination by the Spanish society towards immigrant workers depending on their origin: Latin-Americans and Eastern Europeans are positively discriminated in the labour market, contrasting with the existing negative discrimination towards Africans.

Finally, from the results obtained, we found new ideas for further analysis. For example, we think that the diverse distribution of non-EU women within the Spanish territory could also be affected by variables not considered in this paper. For example, the existence of imbalances in the sex distribution of the population in some rural and less developed regions could explain the growing of mixed couples in those regions (non-EU woman with Spanish man). In those mixed couples, the wife is responsible for the same domestic tasks as Spanish women should be considered. Otherwise, these migrant women would enter the labour market. This is a new reality, not explored in this paper. Further quantitative and qualitative analysis is required in order to extract some conclusions of these new ideas.

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Family and Work Reconciliation: A New Approach to an Old Problem

Anna Matysiak, Daniele Vignoli

1. Background

In the recent decades, the period total fertility rates have decreased in almost all industrialised countries reaching values well below the replacement level. A particularly severe drop was observed in Southern and Central-Eastern Europe where period total fertility rates dropped below the level of 1.35 (so called lowest low fertility). In parallel, a continuous increase in life expectancy has been observed. Altogether, a drop in fertility and a rise in life expectancy have led to a rapid ageing of the European population, despite a high inflow of migrants.

The expected strong increase in the proportion of the elderly, in particularly the oldest old (aged 80+), and in parallel a decline in the proportion of the working-age population may not only hamper the economic growth but also result in financial instability of social security systems. Therefore, policies aimed at mitigation of the negative causes and consequences of population ageing are highly desired. Apart from the indispensable reform of the social security systems an increase in fertility and female employment could undoubtedly bring satisfying results. The problem that remains to be solved is, however, whether it is possible to increase fertility reaching at the same time high women's employment or these two processes stand in a natural contradiction to each other. This issue is indisputably crucial for formulation and implementation of the policies on the national and EU level.

The experience of Europe in the recent decades shows that fertility and women's employment are not necessarily negatively correlated. Although the rise in women's employment observed since the 1960s was accompanied by a strong decline in fertility in all Western European economies the magnitude of this effect differed in a cross-country perspective. As a result since the mid-1980s countries with the highest women's labour force participation have been displaying the highest fertility and vice versa. The trends in Central-Eastern Europe also provide evidence against the existence of the negative correlation between fertility and women's work. During the state socialism fertility as well as women's employment were relatively high. The transformation of the political system was accompanied by a decline in both variables.

As can be concluded from the information given above deeper knowledge on the relation between women's employment and fertility is indisputably required in order to formulate appropriate policies. Although the empirical evidence on the topic is very wide, it is fragmented and often provides contradictory results (e.g. Willekens 1991, Schröder 2005). A lack of systematisation makes it difficult, if not impossible, to draw general conclusions on the size and direction of the effect under investigation.

In this paper we draw on the results of the quantitative literature overview conducted by Matysiak and Vignoli (2008) in order to discuss the relation between fertility and women's work at the micro-level in industrialised economies. We pay special attention to the variation in this association across the institutional and socio-cultural contexts as well as over time. The paper is structured as follows. In Section 2 we give some theoretical overview of the explanations on the changing relation between fertility and women's employment referring to the institutional and socio-cultural contexts. We motivate and define our research objectives in Section 3. In Section 4 we discuss the method of meta-analysis, the techniques applied and we briefly present our findings. They are further discussed in a broader framework in the concluding Section 5.

2. The Old Problem of the Reconciliation between Women's Employment and Fertility

2.1 From the Male Breadwinner to the Dual-earner Family Model

Social research dealing with the growth in mothers' employment and the rise of the dual-earner family has offered different "model families" in response to the issue of work and family reconciliation (Leira 2002). Among the widely known are those by Talcott Parsons (1955), Alva Myrdal and Viola Klein (1956) and Rita Liljeström (1978).

According to Parsons (1955), the first model – the so-called model of specialisation - advocates that only specialised marital roles in household-based activity lead to an optimal use of household resources. The specialisation is justified by innate biological differences between women and men which predispose women to be caregivers and men to be economic providers (male breadwinner model/female carer model). This gender arrangement, dominating in Western Europe in the 1950s, started to deteriorate as a result of modernisation processes brought about by democratisation, changing structure of the labour demand and expansion of the educational system. Rising women's educational attainment has increased the opportunity costs of motherhood and women started to enter employment to a large extent. The Parsonsian task division became no more optimal.

Already one year after Parsons, Myrdal and Klein (1956) proposed a different interpretation of work-family arrangement – the so-called model of sequential employment of mothers. In this family model the role of a man does not change – as the main economic provider he is exempted from the responsibility for household and care duties. What changes is the role of a woman who receives a social right for entering paid employment. Due to household and care duties a mother is, however, expected to sequence family and work, taking up the latter in the next stage of the family life cycle after the children grew up.

Together with the modernisation process and increasing women's education the models with the man as the main economic provider have been gradually outdistanced and replaced by the dual earner model. This model has, however, taken various forms, depending on the gender arrangement and welfare policies. In some countries it is still the task of a woman to perform the majority of housework (dual earner/female double burden). In the others a kind of care-sharing between the partners, the state and the market has been adopted - model of shared societal roles advocated by Liljeström (1978). In the ideal situation gender has no impact on who earns the income, who performs the household maintenance and who does the caring and nurturing work (gender-equity model - McDonald 2000).

The experience of Europe shows that in the last decades a transition from the male breadwinner to the gender-equity model has been taking place. Due to a large differentiation in the rate of change countries are at various stages of the transformation process, with the Nordic ones being most advanced. According to Pfau-Effinger (1998, 2000) the change from one dominant gender arrangement to the other starts when individuals develop new ideas or adopt ideas from different contexts and begin to negotiate a new arrangement. As a result women may act according to new cultural orientations regardless of the fact that the welfare policies referring to a different, traditional set of values and ideas on gender relations sanction their new behaviour (Pfau-Effinger 2000).

2.2 Variation in Socio-cultural and Institutional Settings

Welfare policies in various European countries have indeed reacted differently to the increase in women's employment and changing women's orientations toward paid work. In some countries they immediately started to adjust to the ongoing transformation in the values and norms, whereas in the other the change was more gradual or even very slow. Due to high cross-country heterogeneity of these processes several welfare regimes and gender arrangements have emerged.

The Nordic countries, classified by Esping-Andersen (1990, 1999) as a social-democratic welfare regime, reacted most quickly to the emerging need of women to participate in paid work. Throughout the decades they have been developing a

comprehensive set of social services to the working parents, supporting their full-time integration in the labour market. As a result, the Nordic countries have gradually adopted a dual earner/state carer model (Pfau-Effinger 2000).

Although extensive state intervention in economic activity has also been a characteristic feature of the conservative welfare regime (e.g., West Germany, Austria, Switzerland, the Netherlands) for a long time it was not targeted at supporting mothers' participation in employment. As a consequence hardly any social services for working mothers were provided and the primarily dominant traditional male breadwinner/female carer model has developed into a male breadwinner/ female part-time carer. Only recently, some policies targeting at easing the incompatibilities between family and work have been introduced and the readiness of mothers to participate in employment to a larger extent was expressed in the rising importance of the dual earner model.

Low institutional support to working parents has also been provided in the familialistic welfare regime (Mediterranean countries) where care has been expected to be offered within the large families (Livi Bacci et al. 1992). The limited part-time employment opportunities have additionally supported the prevalence of the male breadwinner/female carer model, still dominant in this part of Europe. Nevertheless, although no actions on the political side have been taken to ease the incompatibilities between family and work so far, the dual earner model more and more often starts to compete with the sole male breadwinner (Salvini 2004). The tensions between the rising women's desire to participate in paid employment and the traditionally oriented welfare state require adjustments from women in the other spheres of their lives.

By contrast, in the liberal welfare regime (UK, US, Canada and Australia) the state interventions have always been limited to assuring functionality of the market. Hence, the individuals have been largely dependent on participating in the labour force to secure their families. High labour market flexibility and well developed private services coexisting with relatively liberal attitudes toward working mothers have finally resulted in an adoption of a dual breadwinner/marketised female carer model.

Finally, in Central-Eastern Europe during the state socialism a dual earner/female double burden model was developed. Women were expected to be workers as well as the main care providers for their families (Geisler et al. 2005, Siemieńska 1997). They were supported in performing their double roles by generous social policies, job guarantees and low competition in the labour market. After the breakdown of the system the economic transformation and rising uncertainty in the markets have been accompanied by a reduction in the public provision of the services. As a result the incompatibilities between family and work have increased, resulting in a severe decline in fertility and employment of women. It is still too early to say which path the Central-Eastern European countries have been follow-

ing. There are, however, signs for emerging heterogeneity in reaction to the ongoing change (Kontula et al. 2004, Neyer 2003).

2.3. Changing Correlation between Fertility and Women's Employment

Although in all Western European countries the rise in women's employment was accompanied by a decline in fertility, the magnitude of this effect was country-specific. Therefore, since the mid-1980s countries with the highest women's labour force participation have been showing the highest fertility and vice versa (e.g., Kögel 2004). This indicates a reversal in the correlation sign between total fertility rate (TFR) and female labour force participation (FLFP). The emergence of the positive correlation between TFR and FLFP is often explained by the cross-country differences in the magnitude of the weakening incompatibilities between childbearing and women's employment (e.g., Castles 2003, Rindfuss et al. 2003, Brewster et al. 2000). In the countries where the institutions did not adjust or adjusted too slowly to the rising desire of women to participate in paid employment women started to develop strategies that allowed them to work on the market avoiding sanctions imposed by the traditionally-oriented welfare state. One of these strategies was restricting the number of children to the contemporary low levels (McDonald 2000, 2002). As a result, in countries where parents were given the opportunities to combine family and work, women's employment and fertility could reach relatively high levels. By contrast, if the conflict between the roles of a mother and a worker remained high, fertility plunged to the very low levels and the employment of women, although on rise, lies behind those of other countries.

Given the explanations for the changing correlation between TFR and FLFP one could wonder whether the considered association is not spurious. Applying vector correction models on time-series data from six developed OECD countries Engelhardt et al. (2004) show that TFR and FLFP are causally related in both directions. They further presume that the simultaneous movements of both variables are caused by common exogenous third variables, such as social norms, social institutions, financial incentives or the availability and acceptability of contraception. This result is consistent with the theoretical model of Apps and Rees (2004) who show that greater availability of childcare and a system of individual rather than joint taxation have a positive effect on TFR as well as the FLFP, producing a positive correlation between the two variables. From the perspective of formulating policy recommendations, an investigation of the interdependencies between women's employment and fertility at the micro-level is, however, required.

3. Association between Fertility and Women's Employment: a Need for Further Investigation

So far a great variety of empirical studies researching the relation between fertility and women's work at the micro-level have been prepared. Although more and more advanced statistical methods are applied the obtained findings are inconsistent. Generally, fertility and women's employment seem to be negatively correlated. There are, however, exceptions to this rule. An insignificant influence of women's employment on the transition to childbirth was found for many countries, beginning with Sweden (Berinde 1999, Santow et al. 2001) and ending in Italy (Bernardi et al. 2005). The evidence of a positive effect of women's employment on birth risks found for East Germany (Kreyenfeld 2004) and Hungary (Róbert et al. 2005) is even more striking. Similarly, studies on entry into employment report an insignificant effect of young children on full-time employment (Drobnič 2000 for lonely mothers in the US, Giannelli 1996 for West Germany, Leth-Sørensen et al. 2001 for Denmark), part-time employment (Drobnič et al. 1999 and Drobnič et al. 1997 for the US, Drobnič 2000 for West Germany) or employment in general (Corijn 2001 for Flanders, Felmlee 1993 for the US, Bernardi 2001 for Italy). Moreover, empirical evidence for the US (Hofmeister 2006), Denmark (Grunow and Leth-Sørensen 2006) and, in the case of one child, France (Grimm et al. 2001) even suggest that mothers of young children are more likely than other women to enter employment.

One of the possible explanations for this great variety of the obtained findings is that the available studies are often difficult to compare. This might be true for several reasons. First, the methods employed to compute the effects under investigation largely vary. Second, even if the methods are similar in nature, different control variables often are included into the model, possibly influencing the size of the studied effect. Third, the age of the children studied is categorised differently across studies and this makes it impossible to compare the strength of the effect. Next, the sample under study is often selected according to the research objectives of the author. Finally, the studies refer to various countries, differing in gender arrangements and welfare policies. Therefore, in order to draw conclusions on the association between women's employment and fertility at the micro-level, a quantitative systematisation of the existing studies is required, allowing standardisation of the available estimates by the cross-study differences.

We undertake this task, taking advantage of meta-analytical techniques. We pay special attention to the variation in the studied effects across the socio-cultural and institutional settings as well as across time. We expect that the relation between fertility and women's work, if negative, is weaker in the welfare regimes characterised by the lower incompatibilities between parenthood and employment. If this hypothesis cannot be rejected, it means that in the period of high women's orientation towards the paid employment higher fertility can be reached, provided that

potential parents are offered appropriate conditions for reconciliation of family and work. Furthermore, we expect that the relationship between fertility and women's work has changed over time.

4. Fertility and Women's Employment: a New Approach Through a Meta-analysis

Within the framework of experimental research, meta-analysis has been employed increasingly in the social sciences (Vemer et al. 1989, Waldorf et al. 2005, Weichselbaumer et al. 2005, Amato et al. 1991, Wagner et al. 2006). It is designed to deal with a large amount of empirical studies, often providing contradictory results.

In order to conduct a meta-analysis, papers researching a topic of interest are collected in a systematic manner. First, estimated coefficients are selected across studies and recalculated in a standardised way into comparable indicators (i.e., effect sizes). The indicators reflect the magnitude of the association in each study. Next, they are combined into single summary indicators. If the computed effects contain a large amount of heterogeneity, regression techniques (the so-called meta - regression) should be applied. Within this analytical framework, the dependent variable denotes the effect sizes and all methodological features of a particular study can be used as control variables.

For the purpose of our analysis we decided to focus on two types of effects: the effect of women's work on childbearing and the effect of young children on females' transition to employment. Furthermore, we limited the selection of the studies only to those that provide sufficient information to asses a causal relationship between work and fertility. Thus, we accepted only longitudinal studies.

Our studies' search strategy, following Stuck et al. (1999), consisted of three criteria: first, to achieve the highest transparency possible, we used Current Contents and EconLit, universal research databases. Second, we checked the references in existing articles. Third, we asked for expert recommendations. Due to the fact that the Current Contents covers articles published in the time span 1990-2006, all selected studies were limited to this publication period.

The search was performed in the seven months from April 2006 to October 2006. In order to collect a representative sample of high quality studies, we merely focused on reviewed articles and chapters in books and monographs, leaving out working papers and internal research reports. Our systematic search was conducted using a specific combination of selected general keywords (work, fertility, childbearing, transition, progression, labour market, employment, etc.).

At the end of the selection process, the search procedure gave us a total of 90 effects of employment on fertility and 60 effects of young children on entry into employment. Our effect sizes are the log odds ratios, the log relative risks and the

estimates of the OLS regressions weighted by the inverse of their variances. The weighting allows us to take statistical significance of the effect into account as well as to indirectly consider the sample size of the original study. In order to study the influence of women's employment on childbearing, we selected the estimates of being employed or, if this was not possible, being employed full-time versus being inactive, unemployed or non-employed. Our analysis of the effects of fertility on women's employment focused on children aged six or less. This was the most frequent age interval, in which the age of the children was classified. Many authors, however, used other age intervals. In order to maintain coherence across studies, we recalculated the original estimates using interpolation techniques.

Due to a large amount of heterogeneity in the obtained effect sizes they were analysed in the meta-regression framework. In other words the effect sizes were standardised for the differences in the original studies, such as: the socio-cultural and institutional context analysed, cohorts considered, type of the transition and measurement employed (e.g., birth order, type of employment, type of non-employment, definition of the reference category, definition of the child's age variable, etc.), sample selected, method applied, type of the data used and the original model specification. The robustness of the meta-regression estimates was verified by conducting a sensitivity analysis.

In order to investigate the differences in the studied effects with respect to the institutional and socio-cultural context, we applied the Esping-Andersen classification of the welfare regimes (Esping-Andersen 1999). As we included the Eastern European countries into our analysis, we added two new clusters: socialist, when the original analysis refers to the period before the breakdown of the socialist regime and post-socialist in the opposite case. We included contemporary East Germany into the latter cluster. Although the country adopted the West German legal framework following the fall of the Berlin Wall, the female employment patterns and the attitudes toward working mothers largely differ in both parts of Germany (Matysiak et al 2008). We succeeded in covering all welfare regimes in the analysis of the effect of women's employment on childbearing. Unfortunately, due to an insufficient number of available studies on the effect of young children on mothers' employment entry in the socialist, post-socialist and familialistic welfare regimes (less than five per regime) we decided to concentrate only on the three remaining welfare regimes: conservative, liberal and social-democratic ones, which lowers the number of effect sizes to 55.

The complete list of the papers included in the meta-study is reported in Matysiak and Vignioli (2006), while detailed information on the methodological issues concerning meta-analytic techniques and description of the empirical findings are presented in Matysiak and Vignoli (2008). Here, in line with the objective of the paper, we limit our discussion to the variation in the effect sizes across time and space. The results are presented in Table 1.

Table 1: Meta-regression estimates

		Effect of children aged 0 to 6 on women's employment entry	Effect of women's employment on childbearing
Welfare regime	Conservative	-1.06**	-0.29***
		(0.47)	(0.07)
	Liberal	-0.79*	-0.35**
		(0.48)	(0.16)
	Socialist	-	-0.03
			(0.06)
	Post-socialist	-	0.30***
			(0.09)
	Familialistic	-	-0.49***
			(0.06)
	Social-democratic	ref.	ref.
Cohort	Birth cohort >= 1960	-0.57***	0.17***
		(0.17)	(0.03)
	Birth cohort < 1960	ref.	ref.
No. of studies		55	90

NOTE: *** < 0.01, ** < 0.05, * < 0.1. Standard errors are reported in the parentheses.

The results are standardized for the construction of the variable describing the effect of children on mothers' employment entry or the variable describing the effect of employment on childbearing, the type of the transition, the sample selected, the inclusion of non-white populations (this regards mainly studies on the US), the method applied, and selected covariates included in the original studies (see Matysiak and Vignoli 2008).

The study covered following countries: a) conservative welfare regime: Belgium (Flanders), France, The Netherlands, Switzerland, West Germany, b) liberal welfare regime: UK and US, c) socialist welfare regime: Poland, Hungary, Czech Republic, d) post-socialist welfare-regime: East Germany, Hungary, Czech Republic, e) familialistic welfare regime: Italy and Spain, f) social-democratic welfare regime: Denmark, Finland, Norway, Sweden.

The first and main finding of our meta-study is a high variation in the analysed effects among the welfare regimes. The negative effect of children aged 0 to 6 on mothers' employment entry is definitely strongest in the conservative welfare regime and lowest in the social-democratic regime. The liberal institutional setting lies in-between these two poles. The negative effect of women's work on childbearing is strongest in the familialistic, liberal and conservative welfare regime and lowest in the post-socialist one. The socialist and social-democratic welfare regimes are characterised by the effect of females' employment on childbearing at an intermediate level.

As regards the variation in the effect sizes across cohorts the multivariate analysis indicates that the negative effect of women's work on fertility has decreased over time. Exactly the opposite is concluded on the effect of young children on women's employment entry. We address these findings in more detail in the next section.

5. Micro-level Variation in the Association between Fertility and Women's Employment over Time and Space

Our empirical findings are in line with the hypothesis that the relation between women's employment and childbearing strongly varies across the socio-cultural and institutional settings.

The analysis revealed that the conflict between employment and family is relatively low in the social-democratic and socialist welfare regime. In our opinion, this is related to the high institutional support to working mothers in both welfare regimes. Moreover, in the social-democratic welfare regime, the incompatibility of employment and childcare is reduced by relatively liberal attitudes towards working mothers, whereas in the socialist regime it was facilitated by strong job guarantees, lack of competition in the labour markets and socialist ideology forcing high fertility and high women's employment. Nevertheless, women's employment seems to depress fertility least in the post-socialist welfare regime. This finding seems to be striking since following the fall of the socialist regime the Eastern European countries experienced a severe fall in women's labour force participation and fertility, accompanied to a large extent by a withdrawal of the state from institutional support of working mothers (e.g., Kotowska 1999, Stropnik 2003). Furthermore, studies by Muszyńska (2007: 93-96) and Lück and Hofäcker (2003) reveal that attitudes towards working mothers in the post-socialist countries are relatively traditional when compared to the rest of Europe. We believe, however, that the observed positive influence of women's employment on childbearing may be the result of a strong income effect. Rapidly rising aspirations of individuals in Eastern Europe in the course of economic transformation, state withdrawal from financial support for

families and relatively low wages compared to the old EU member states may be a source of strong economic necessities that restrain one-breadwinner-couples from family formation. Moreover, individuals may be less willing to bear children when their economic situation is uncertain. Women on temporary contracts, on the risk of losing a job, unemployed or married to men with unstable employment may be more reluctant to have children due to economic problems and the fear of jeopardising chances to maintain or find employment in case of pregnancy and childbearing. Finally, following Kreyenfeld (2004), the positive impact of employment on birth in the post-socialist countries may also be due to a highly internalised picture of the working mother, inherited from the past.

In the remaining welfare regimes, the conflict between work and family is much stronger and its magnitude increases as we move from liberal to conservative and familialistic welfare regimes. These results are consistent with our expectations. The high labour market flexibility in the UK and the US allows mothers to enter employment fairly rapidly after a career break, which may compensate in part for the lack of public support for working parents. In contrast to the liberal welfare regime, the conservative and familialistic institutional settings are characterised by relatively rigid labour markets and more traditional attitudes towards working mothers, additionally to low institutional support for working parents.

Apart from the high regional variation in the studied effects, we found a significant change in their magnitude over time. Our results undoubtedly show a reduction in the negative impact of women's work on fertility. On the other hand, however, it turns out that the negative influence of young children on women's employment entry has even strengthened. In our opinion a complex interplay of several factors is responsible for this state of affairs. Changing attitudes towards working mothers and evolving family policies directed to work and family reconciliation in many of the developed countries in the recent decades have improved the conditions for childbearing for working women, albeit at very diverse rates. Hence, these cultural and institutional factors might have contributed to a decline in the negative impact of women's work on fertility. On the other hand, however, increasing competition in the labour markets and consequently rising requirements of employers as regards mobility and availability in the globalising world have diminished chances of employment (re-)entry for mothers who withdrew from the labour force for the period of delivery and care or delivered while being out of employment. The anticipated inability to find a job or return to work after birth may force women to postpone childbearing until establishing a relatively good position in the labour market. In this situation women who plan to have a child will self-select themselves into employment prior to childbearing. Such behaviour weakens the observed negative effect of employment on fertility, but in the conditions of increasing uncertainty in the labour markets it may lead to a continued postponement in childbearing and a further decline in fertility. Finally, apart from the devel-

opments described above, an increase in the negative impact of young children on women's employment entry might also result from a change in the characteristics of women participating in the labour force. Since in the past, it was common for women to stay at home, those who worked were very likely to be strongly work-oriented. For this group of women having children did not constitute a large obstacle to work. Nowadays, the majority of women participate at least for some time in paid employment and the highly work-oriented constitute only a fraction of them.

Both, the regional and time variation of the studied effects suggest that the correlation between women's employment and fertility is at least partly spurious, possibly caused by a simultaneous influence of common antecedents. This implies that regional and/or temporal variations in institutional factors (like childcare subsidies, taxation policies and other forms of family support), structural factors (e.g., labour market rigidities or high uncertainty in the markets) and socio-cultural factors (such as attitudes toward working mothers and perception of the gender roles) have been important in determining the magnitude of the conflict between work and family. This finding is consistent with that of Rindfuss and Brewster (2000), Rindfuss et.al. (2003), Kögel (2004) and Engelhardt et.al. (2004) that country-specific effects mediate the correlation between fertility and women's work at the macro-level.

The direction of future demographic as well as economic developments may depend significantly on whether or not Europe succeeds in implementing reforms necessary to react to the ongoing population changes. Our results suggest that policies designed to counteract the negative consequences of the ageing process should be targeted at promotion of gender equality and creating appropriate conditions for parents to combine family with work. At the time being it seems to be the only solution for increasing fertility as well as women's employment. Moreover, if increasing flexibility of the labour market leads to fertility postponement, policies aimed at eliminating the uncertainty, unemployment and poverty risks among the youth are to be considered. In other words, it is the flexibility that helps the reconciliation between family and work and does not destabilise the position of young men and women in the labour market that should be supported.

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VI. Issues in Retirement

Policy-making in Ageing Labour Markets: The Case of Hidden Early Retirement in Germany

Martin Brussig, Christina Wübbeke

1. Introduction

Compared with other European societies, the institutional arrangements and incentives in Germany against early retirement have been reformed faster and more comprehensively during the last decade. However, two pathways survived leading to an early exit from the labour market.[1] For employed persons, there is the opportunity of 'part-time work for older employees' (Altersteilzeit), which is a form of bridge employment: Although not restricted to a specific way to phase out the work life, in most cases people split the total period of 'part-time work' into a first part of full work and reduced income, followed by a second part without work at all, but still receiving income and paying pension contributions. For unemployed persons, there is the opportunity of getting unemployment benefits (UB) without the obligation to search a job and quit unemployment as soon as possible (Leistungsbezug unter erleichterten Voraussetzungen – receipt of benefits under facilitated conditions, according to § 428 SGB III / German Social Code III), which can be seen as a kind of 'bridge unemployment'. This paper focuses on the second form, the 'facilitated receipt of benefits for older persons' (FRB). Our paper describes socio-economic characteristics of persons who benefit from the regulation for a FRB and reports on their motivation to take it up. Based on a regression analysis, we analyse factors on a micro level influencing individual decisions for or against the FRB. While the FRB looks like a form of early retirement, it might be used by persons who search for employment only selectively as a protective shield against pressure from the Public Employment Services (PES) to accept any job. From the perspective of institutional theory, the results show for the German case inherent contradictions in labour market policies aiming to cope with an ageing labour force and mass unemployment especially among the older workers at the same time.

The paper is structured as follows: First, the institutional background for transitions from work into retirement will be introduced. The regulation for the 'facili-

1 This paper is based upon the social laws as at May 2007.

tated receipt of benefits' (FRB) will be explained as well. Next, we present recent developments of unemployment rates among older persons and the effect of the FRB on the volume and structure of registered unemployment. We turn then from the aggregate-level to the micro-level to analyse the motivation of the persons making use of this regulation and determinants which influence individual choices to opt for the opportunity of a FRB. Finally, our paper concludes with a summary.

2. Employment of Older Persons and Early Retirement in Germany: Recent Reforms

During the last decade Germany experienced a paradigm shift from 'active labour market policy' to 'activating labour market policy'. Typical characteristics of activating labour market policy compared with active labour market policy are (i) the focus on individual responsibility to quit unemployment, (ii) working with incentives for job seekers, employers and employment agencies, (iii) tightened criteria for the acceptability of job offers and demands towards recipients of unemployment benefits in conjunction with a more pronounced policy of sanctions and (iv) cutbacks in benefits. First steps have been taken in 1997 with the implementation of the German Social Code III (Sozialgesetzbuch (SGB) III) which deals with unemployment insurance and employment agencies. The development went on with the 'Job-AQTIV' Law (2001) and the Four Laws for Modern Services for the Labour Market ('Hartz I – IV', 2003/04). Similar developments occurred in other European countries. In international comparisons, Germany is widely regarded as a latecomer in labour market reforms (Funk 2006, Sproß 2005).

At the same time, pension reforms aiming at containing early retirement became effective. This paradigm shift in labour market and pension policies has three implications specifically for older jobseekers:

First, older unemployed persons gain in importance as a special target group of labour market policy. Their participation in several measures of labour market policy, such as training and job creation schemes, is a special category in the statistical monitoring of the labour market.[2] (However, labour market statistics for the older workers are distorted, as will become clear below.)

Second, there are some instruments and political campaigns designed specifically for older unemployed, such as the exemption of the employer from paying unemployment insurance contributions for hiring an unemployed person of age 55 and above (§ 417 SGB III) or a temporary income subsidy for older persons which

2 Other target groups besides the older unemployed (from the age of 55 on) are young persons (below the age of 25), persons with disabilities and long-term unemployed.

pick up work with a lower income than they had before (§ 421j SGB III). Other instruments offer better conditions for older persons, such as wage subsidies for employers who hire new employees. The variety of instruments is hard to oversee even for experts, but for employees at employment agencies as well, and all the more for employers. The effects of the instruments vary (see Eichhorst 2006, ZEW et al. 2006), but they are clearly not sufficient to remedy the risk of long term unemployment for the older workers.

A third implication is that there are fewer opportunities for early retirement. Since 1997 entries into pensions before the regular age of 65 are coming with deductions which make them less attractive (Büttner 2005, Brussig et al. 2006b). From 2006 onwards, the earliest entry possible into pension due to unemployment is raised from 60 to 63 years. Also in 2006, the maximum duration for benefits from unemployment insurance for older workers was reduced to 18 months. Thus, it is no longer possible to build exit passages before the age of 63.5 which consist of unemployment insurance payments and lead into full pensions. Moreover, the replacement of the former unemployment assistance by the new 'unemployment benefit II' (UB II, Arbeitslosengeld II) in 2005 has impaired the financial situation for many of the older long-term unemployed, because the definition of neediness has been tightened and in addition UB II is only a flatrate basic income support and therefore in most cases lower than the former unemployment assistance, which was geared to the antecedent wage. Thus, the recent reforms have increased the pressure on older unemployed persons to take up new work.

Another consequence is that negotiations of early retirement shifted from the state level to the level of employers' associations and unions (Tarifpartner) (Trampusch 2005), which resulted in a shift of the costs of early retirement, placing more of the financial burden to those employers who wish to implement early retirement programs and less to the community of (all) tax payers. This, in turn, leads to a segmentation of entry chances into early retirement schemes and in a growing variety of early retirement schemes.

However, the reform of the institutional frame is still regarded as an 'incomplete paradigm shift' (Eichhorst 2006): 'The tracks are still not leading in the right direction' (Eichhorst et al. 2005: 1). One of the main reasons for the sceptical judgement is the option of a 'facilitated receipt of benefits' (FRB) for persons of age 58 and more. This option – for details see below – enables receiving unemployment benefits without being obliged to search for work on condition that the recipients enter a deduction-free pension as early as possible. Thus, a large number of unemployed persons of age 58 and above is not accessible for an activating labour market policy. From this perspective, the so-called '58 rule' works as a hidden early retirement program for the unemployed.

The FRB for unemployed persons of age 58 and above was introduced into German labour market policy in 1986. The FRB survived for more than two dec-

ades, although it was always on a temporal basis, lasting never more than two years. At first available only for persons receiving insurance-based unemployment benefits, it was soon extended to persons with tax-financed (and means-tested) unemployment assistance. With the commencement of the German Social Code II (SGB II) in January 2005 the unemployment assistance and the social assistance for persons able to work[3] were replaced by the new unemployment benefit II (UB II), which is administered by a new structure of agencies, which we will refer here to as BIS-centres.[4] According to the new law, the option of FRB was now available for recipients of UB II. This was a further extension, since former recipients of social assistance who could claim UB II had the possibility to opt for a FRB for the first time. Originally, the FRB was part of a policy to ease tight labour markets by reducing labour supply in particular by shortening the work life (see Trampusch 2005). Also the maximum duration of insurance-based unemployment benefits has been extended several times, resulting in sequences starting from age 57 1/3 into retirement. In some cases, the early retirement started already at age 55 or even earlier.[5]

3. 'Receipt of Benefits under Facilitated Conditions' – What Does it Mean, and for Whom?[6]

Persons opting for a 'facilitated receipt of benefits' are exempted from duties which come along with drawing unemployment benefits, such as proving job search activities, visiting the employment agency regularly or accepting any job offer and offers to attend training courses or job creation schemes. The main obligation is to enter retirement as early as a deduction-free pension is possible. Normally, persons who receive unemployment benefits are allowed to leave their home – e.g., for vacation – for three weeks per year. Under facilitated conditions, it is 17 weeks per year. Persons opting for a FRB are still entitled to get job announcements and to be registered as 'job seeking'. Statistically, these persons do not count as 'unemployed', but as 'non-unemployed job seekers', as for instance persons do who search out of employment for new work. As a consequence, persons in FRB are excluded from

3 "Social assistance" (Sozialhilfe) is a tax-financed basic income support for persons in need. Unlike the unemployment assistance it is a flat rate payment, which did not depend on preceding employment.

4 The name refers to the title of the German Social Code II which can be translated as "Basic income support for job seekers".

5 Exit at age of 55 (or earlier) was possible when means-tested unemployment assistance was included. Another way to lengthen the early retirement further was to include times of reduced work (Kurzarbeit) up to two years.

6 The optional facilitated receipt of benefits is regulated in § 428 SGB III and § 65 SGB II for recipients of unemployment benefit and UB II.

training courses or job creation measures, because these measures mostly require unemployment status.

A person who opted for the FRB could reverse the decision within a period of three months. When reversed, this person will be treated as a 'regular' unemployed person, but is nevertheless obliged to enter a deduction-free pension as early as possible.

Being under the '58-rule' might have affected old-age provisions of the recipients of unemployment benefit if a deduction-free pension was available before the age of 65. Under these circumstances, a person under the '58-rule' had to draw a pension even if the maximum duration of unemployment benefit was not reached and further pension entitlements could have been collected.

According to the conditions of UB II, it is strictly means-tested and available only if all other sources of income – including income from household members – are not sufficient to make a living. The opportunity to get a pension would normally count as income. For recipients of UB II, the obligation within the 'facilitated receipt of benefits' to enter a pension when the regular pension entry was reached, turned out as a protection against a compulsory pension entry at the earliest possible age, which would come with significant deductions up to 18 % of the earned pension entitlements.

4. Visible and Hidden Unemployment Among Older Persons 1996 – 2006

The German Federal Employment Agency (Bundesagentur für Arbeit, BA) counts unemployed persons at age 50 to 64 as 'older unemployed'. In August 2006, they amounted to 1.12 Million persons, among them about 552,000 unemployed persons at age 55 and above. About a quarter of all unemployed persons are 50 years or older. Compared to the figures of the previous year (August 2005), the number of older unemployed persons has shrunk by 6.1 %, which is less than the reduction of the total unemployment during this time (-8.9 %). Even worse was the development for unemployed persons at age 55 and above (-4.5 %). The number of unemployed women in East Germany at age 50 and above has even grown by 2.4 %.

In 2006, the unemployment rate for the age group 55 to 64 was 14.3 % in West Germany and 23.5 % in East Germany, compared to an average of 12.1 % and 21.8 %.[7] Older persons are unemployed above average in both parts of the country.

7 For these figures, the number of unemployed persons is related to (a) the number of all employed persons covered by social insurance plus (b) the number of unemployed persons within an age group. This concept differs from the usual German counting method, which includes in the denominator besides (a) and (b) the number of dependent employed persons below compulsory social insurance limits

Unemployment rates for the older workers would be considerably higher if persons under facilitated conditions for unemployment benefits were included. In June 2006, they amounted to about 257,000 persons of age 58 to 64. Accordingly about 63% of all persons defacto unemployed in this age group did not show up in the unemployment statistics. Figure 1 shows for 1999 to 2006 the number of unemployed persons at age 50 to 57, the number of registered unemployed persons of age 58 to 64 and the number of persons under facilitated conditions for unemployment benefit, i.e., not registered unemployed persons of age 58 to 64.

Three trends can be seen in Figure 1: First, the number of registered unemployed older persons tends to fall since 1999, which is the 'good news' for a labour market policy targeting people at age 50 and above. Second, however, the total number of unemployed older persons changes with the business cycle. Third, and most important, the number of persons who opted for the 'facilitated receipt of benefits' (FRB) has grown over time and so has the proportion of hidden unemployment since 1999. Since 2003, more than half of all persons without work at age 58 to 64 are in the less visible group of persons with 'facilitated receipt of benefits'.

The reservoir of unemployed people is even larger, because persons in public employment opportunities (Arbeitsgelegenheiten)[8] count neither as employed nor unemployed. In 2005, on average 224,000 persons were in public employment opportunities, among them 43,500 persons of age 50 and above. In 2005, 630,000 new public employment opportunities started, with 112,000 (17.8 %) people aged 50 and above. Additionally, in 2005 about 11,000 unemployed persons at the age of 58 and above who were in a special federal program of public employment opportunities had to be added. Public employment opportunities have an average duration of 5.7 months, a work time of 28 hours/week and an 'allowance for special expenditures' of 1.25 Euro/hour. Finally, there is a third stream of hidden unemployment, constisting of persons in labour market programs who are also not counted as unemployed for the time being in the program.

All in all we can say that the level of unemployment among the older workers has remained above average for the last years. Only the composition of registered und unregistered unemployment has changed towards the latter.

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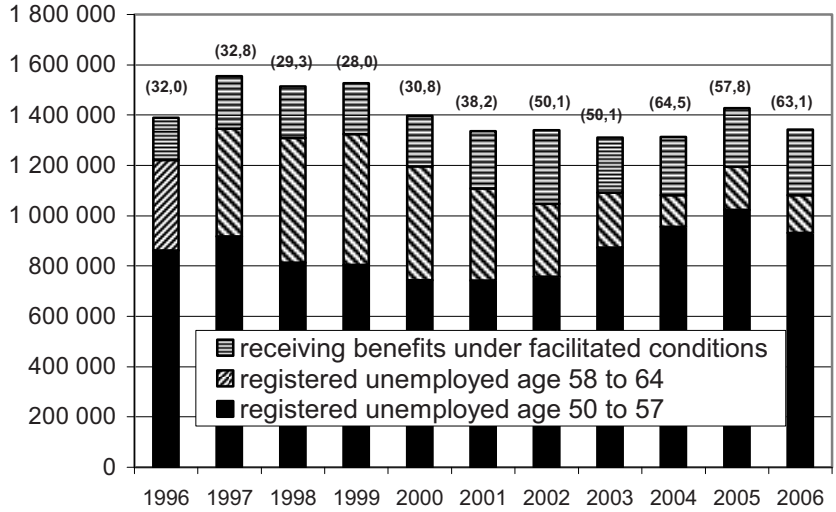
and civil servants (Beamte). Neither of both concepts is internationally comparable, which would require to include self-employed persons as well.

8 Arbeitsgelegenheiten (§ 16, 3 SGB II) are a special form of public job creation. Persons in Arbeitsgelegenheiten do not receive wage or salary, but merely an 'allowance for special expenditures' (thus the popular label of '1-Euro-Jobs') and these persons do not have labour contracts with basic rights. Legally, they are in 'contractual relations sui generis' (Rechtsverhältnissen eigener Art).

Figure 1: Older persons without work, registered and not registered as unemployed (age 50 to 64, 1996 – 2006)



From 2003 onwards, only persons in FRB receiving UB (Arbeitslosengeld) are counted, i.e., persons in FRB and receiving UB II (Arbeitslosengeld II) (2005, 2006) or receiving unemployment assistance (Arbeitslosenhilfe) (2003, 2004) are excluded.
Figures in brackets above columns: proportions of persons receiving facilitated benefits (age 58 to 64) of all unemployed persons age 58 to 64 (=hidden unemploymend due to FRB).
Source: Bundesagentur für Arbeit; Strukturanalysen der Bundesagentur für Arbeit 1998-2006.

5. Empirical Analysis: Socio-economic Characteristics of Persons Opting for a 'Facilitated Receipt of Benefits' and Factors Influencing Individual Choices

5.1 Research Question and Preliminary Hypotheses

Why do some people choose the 'facilitated receipt of benefits' (FRB), while others do not? Aggregate data, institutional analysis about Public Employment Services (PES) and experiences from early retirement programs point to three main hypotheses:

First, the FRB is a form of early retirement for unemployed persons with little motivation to re-enter employment. It is hard to conceive that a person with unem-

ployment benefit (UB) entitlements which last until retirement age can be activated against his or her individual motivation. Indeed, until the mid-1990s it was possible to enter a pension from age 60 on after receiving UB entitlements lasting up to 32 months, which would have led at age 57.3 straight out of the labour market. However, these conditions do not exist today (see Section 2). If we find an orientation towards retirement, the first hypothesis would be corroborated.

Second, the FRB could serve the interests of PES in focussing on unemployed persons with good chances of getting a new job. A strong indicator is the constant rise of the rate of people under the '58-rule' (see Figure 1). However, we cannot test this hypothesis directly, since the individual data contain only scarce information about the influence of PES on the decision to opt for FRB.

Third, it is possible that people choose FRB to gain autonomy from the PES, while still looking for work. There are strong requirements to accept lower standards in pay or travel distance to work, thus the PES might appear more as a threat than as support for older jobseekers. Moreover, organisational reforms within the PES introduced incentives for a 'creaming' strategy within the PES and towards their customers which might lower expecations of older job seekers towards the PES further.

5.2 Data Basis: "Life Situation and Social Protection in 2005"

The following analysis is based on the cross sectional survey 'Life Situation and Social Protection in 2005' which was conducted on behalf of the Institute for Employment Research (IAB) throughout the Federal Republic of Germany between November 2005 and March 2006. The study aimed at an examination of the effects of the recent welfare state reform in Germany, which was initialised by the commencement of the Social Code II in January 2005. With this reform the old two-track system of unemployment assistance (Arbeitslosenhilfe) and social assistance (Sozialhilfe) was replaced by the new integrative system of UB II (Arbeitslosengeld II) for all needy persons able to work. The survey addressed the recipients of the UB II in January 2005 on the one hand and the recipients of former unemployment assistance, who lost their entitlement to benefits as consequence of the reform, on the other.

The topics of the survey include the material circumstances, health status and the (psycho-)social and family situation of the respondents, their education and work history, their receipt of benefits, their participation in employment and training schemes sponsored by the public employment service, their old-age provisions and their plans for the transition from work to retirement.

In the main study 20,832 persons capable to work between age 15 and less than 65 years were questioned, mainly by telephone, partly, however, also face-to-

face. As a result of incomplete address data the recipients of UB II were included completely in only 266 of 439 districts of the Federal Republic of Germany. In the remaining 173 districts only recipients of the UB II, who had drawn unemployment assistance in December 2004, were interviewed, so that in these districts, above all, former recipients of social assistance are missing in the study.

The following analysis is based upon the data of those respondents who were entitled to 'facilitated receipt of benefits' (FRB). All people in this group either received unemployment benefit or unemployment assistance (from 2005 on: UB II) after reaching their 58th birthday. It had no effect on the access to this group if the interviewed individual still drew benefits or not at the time of the interview. In order to prevent biased results the study was limited to those 266 districts for which the Federal Employment Agency had a file on every recipient of UB II in January 2005. Comparisons between the selected group and the nationwide population made evident that the interviewed persons in the 266 districts were not representative in every respect: Recipients living in East Germany were overrepresented.[9] In consequence the descriptive analyses had to be performed separately for East and West German districts. The number of individuals remaining after filtering out the incomplete districts made a total of 1,012 persons (unweighted).

5.3 Characteristics of the Examined Population

We have to stress that the survey addressed recipients of UB II, who were mostly former recipients of the two earlier equivalent systems (unemployment assistance and social assistance). That means that we do not have information about persons bridging the gap between employment and retirement pension by claiming the insurance-based (regular) unemployment benefit or other insurance-based payments, often organised and further subsidised by company-based early retirement programs. This (here unobserved) group would not need to claim UB II. Although these persons represent a large and important group of persons within the facilitated receipt of benefits, one could assume an "early retirement constellation" according to our first hypothesis (see above). In other words: Although we have only a selected group of recipients under facilitated conditions, from the point of our

9 According to the statistics edited by the German Federal Employment Agency (Bundesagentur für Arbeit, BA), 31 % of the people aged between 55 and 64 years and having been in receipt of UB II in January 2005 lived within the borders of the former GDR, whereas the total share of this group in our study makes 42.2 % (weighted) after the exclusion of incomplete districts (BA 2005). For the group here in focus – aged between 58 and 64 years – we do not have comparative figures from the statistics of the German Federal Employment Agency.

empirical analysis it is the more interesting group to learn about the functioning of facilitated benefits.

A further characteristic of the examined population is their heterogeneity. As a consequence of the reform of the German welfare system, people emerging from different social security systems into the new UB II are included. The largest group is represented by the recipients of former unemployment assistance with a share of 61.7 % in West and 73.7 % in East Germany (see Table 1). This difference might be caused by the comparatively high labour participation in the former German Democratic Republic (GDR). Unlike the former social assistance as a solely need-dependent benefit, the claim for unemployment assistance was in addition related to a preceding employment covered by social security. In contrast, the recipients of former social assistance make a percentage of only 8.6 % in East Germany, but a share of 23.2 % in West Germany. The interviewed persons receiving an insurance-based support in December 2004 (especially unemployment benefit) are more or less equally represented in both parts of the country (13.6 % former GDR, 11.6 % former FRG). Circa 4 % of the respondents had not received one of the above mentioned payments before the reform of the German welfare system was initiated.

The different origin of the interviewees is reflected by the duration of unemployment[10] the respondents already have experienced before being entitled to a facilitated receipt of benefits. Table 1 combines the percentiles of this duration, differentiated between East and West and according to the kind of payment received in December 2004. The most extended unemployment durations were found in the group of the recipients of former social assistance: Half of them left regular employment at least 7.3 years (East) or 8.4 years (West) ago, whereas in either parts of Germany the shortest unemployment durations can be found among recipients of unemployment benefit or maintenance allowance (median West: 2.8, East: 1.6). In between we find the recipients of former unemployment assistance (median West: 4.0, East: 4.7). This means that the examined population is characterised by a long abstinence from employment: 50 % of all interviewed persons above 58 years were at the beginning of their 'period of decision'[11] between 4.2 (West) and 4.3 (East) years not employed.

10 The calculations refer to the duration of not being employed in more than minor employment.

11 With 'period of decision' we mean the period of time, in which the interviewee had a right to claim FRB; cf. Table 1/ annotations: **.

Table 1: Composition of the examined population: kind of received benefit in December 2004 and duration of unemployment since the end of the last more than minor employment (weighted)

			Duration of unemployment (until the beginning of the period of decision**) in years			
Kind of benefit	Number	Percent	Number of observations with valid duration	25 % percentile	Median	75 % percentile
West Germany						
Unemployment benefit, maintenance allowance	75	11.6	73	0.42	2.83	6.67
Unemployment assistance	440	61.7	435	1.58	4.00	7.50
Social assistance*	166	23.2	130	4.08	8.42	23.17
None of it	32	4.5	26	0.17	1.08	9.33
Total	713	100.0	664	1.42	4.17	8.58
East Germany						
Unemployment benefit, maintenance allowance	67	13.6	66	0.17	1.58	3.67
Unemployment assistance	367	73.7	357	2.25	4.67	8.92
Social assistance*	43	8.6	37	1.50	7.33	12.42
None of it	21	4.2	21	0.17	3.08	10.50
Total	498	100.0	481	1.50	4.25	8.67
East and West total	1,211	100.0	1,145	1.50	4.17	8.67

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

* Without persons, who received social assistance in addition to unemployment benefit, maintenance allowance or unemployment assistance.

** This period either begins with the 58th birthday, if the respondent is in receipt of benefit at this age or with the entry into the receipt after the 58th birthday.

The proportion of people claiming FRB in the examined population strikes as exceptionally low: Whereas more than 80 % of the older recipients of unemployment benefit used the FRB in recent years,[12] it were only 69.7 % of the examined East German and 52.1 % of the West German recipients of UB II (Table 2). Three reasons might help to explain: First, a facilitated receipt of benefits is more attractive for persons receiving insurance-based unemployment benefit with a clear roadmap into retirement than for persons who receive means-tested UB II. Second, former recipients of social assistance had the opportunity to make use of FRB only since getting UB II. Therefore many of them might not have been informed about this regulation or have not decided whether to participate in FRB at the time of the interview. Third, a further reason might be different management systems of local agencies dealing with unemployment benefit (PES-agencies) and BIS-centres dealing with UB II. Since about 50 % of recipients of UB II are not registered as unemployed[13], the main criteria for BIS-centres is not only outflow from unemployment, but outflow from transfer dependence (receipt of benefits) as well, whereas local agencies which deal with recipients of unemployment benefit focus on outflow from unemployment as most important benchmark. Thus, BIS-centres might attach less importance to informing people about and guiding them into the FRB than PES-agencies.

Table 2: Users and Nonusers of the 'facilitated receipt of benefits' (FRB) in the examined population (weighted)

	West Germany		East Germany		Total	
	Number	Percent	Number	Percent	Number	Percent
User	341	52.1	325	69.7	666	59.4
Nonuser	313	47.9	141.5	30.3	455	40.6
Total	654	100.0	466.3	100.0	1,120	100.0

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

12 Figure 1 presents ca. 60 % of recipients of unemployment benefit under facilitated conditions of all registered unemployed plus persons within the FRB. Calculated only against persons with unemployment benefit (i.e., disregarding recipients of UB II), the share amounts to ca. 80 %.

13 Other important reasons to receive UB II while not being unemployed are low income from present work, and exemptions from job search obligations, as for instance for (one) parent with a child under the age of three.

5.4 Self-reported Motivation of Participants

Since we want to know which persons accepted the opportunity for a 'facilitated receipt of benefits' (FRB), it might be useful to analyse the self-reported motives why they did so. In the questionnaire, they had the opportunity to react on nine standardised items which covered different aspects which might be regarded as incentives for the FRB. The majority would point to an early retirement motivation, but two items would reflect a motivation to gain autonomy from the BIS-centre (see Section 5.1).

Indicators for the 'early retirement'-interpretation are:

a) My health doesn't meet employers' demands.
b) When I decided for the FRB, I trusted that I'll get unemployment benefit (UB) and unemployment assistance (UA) until retirement age.
c) I don't want to work any longer.
d) I don't meet job requirements anymore.

Indicators for the 'autonomy'-hypothesis are:

e) I don't want to accept every job offer.
f) I don't want to apply anytime and everywhere.

Furthermore, there are two items which reflect a fundamental scepticism towards the activities of the responsible agency: 'I won't get any job offers by the agency' (g), and 'I won't get any offers for further training etc. by the agency' (h).[14] Finally, there was an open category of 'other' reasons.

The overall ranking of these self-reported motives does not give a clear hint whether the FRB is regarded as another form of early retirement by the users or as instrument to search for a new job under less pressure. Rather, it seems to be a mixture between both. Scepticism about support from the agency is widespread (more than 90 % of the interviewees approved statement g and more than 50 % statement h) and in between is an indicator for early retirement (more than 80 % accepted statement b). Although indicators for autonomous job search are not among the top three, they are of significant importance. A rather striking result is that only 12.7 % of the West German and 8.5 % of the East German persons in the FRB declared that they did not want to work anymore. So the main reason for older unemployed to withdraw from the labour market via FRB seemed to be, that they did not see a realistic chance neither to get re-employed nor to get effective assistance from the agency.

14 These items could serve as an indicator for the second hypothesis (strategic behaviour on behalf of the PES or BIS-agency), although for a test it would be better to analyse agencies themselves and not persons ('clients') dependent on the agencies.

In a second step, we analyse rankings for different socio-economic groups. Since the decision for and against early retirement is influenced by job chances and household characteristics, we differentiate for marital status (as a simple indicator for household characteristics) and skill level (as a simple indicator for job chances). Due to different samples, results are shown separately for East and West German users.

Although there seems to be a greater variation of self-reported motives among East Germans than among West Germans, the main result is that there is only little variation in top- and bottom-ranked motives. Even between groups where the ranking order of self-reported motives varies, no distinct pattern emerges which would indicate clear support for one of the hypotheses.

Table 3: Self-reported motivation for a facilitated receipt of benefits, marital status (West)

	All in %	Married Rank	Di-vorced Rank	Widowed Rank	Single Rank
No job offers by agency	93,59	1	1	1	1
Trusted in UB/ UA until retirement	81,19	2	2	2	2
No other offers (further training etc.) by agency	52,59	3	3	5	3
Don't want to accept every job	40,04	5	4	3	4
Health not good enough	36,10	4	5	4	6
Don't want to apply anytime/ everywhere	32,78	6	6	7	8
Don't meet job requirements	31,33	7	7	6	5
Other	22,88	8	8	8	7
Don't want to work	12,70	9	9	9	9

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

Table 4: Self-reported motivation for a facilitated receipt of benefits, skill level (West)

	All in %	Unskilled Rank	Skilled Rank	Foremen etc. Rank	University degree Rank
No job offers by agency	93,57	1	1	1	1
Trusted in UB / UA until retirement	81,13	2	2	2	3
No other offers (further training etc.) by agency	52,49	3	3	3	2
Don't want to accept every job	39,83	4	4	5	4
Health not good enough	36,23	5	5	4	5
Don't want to apply anytime / everywhere	32,90	7	7	6	8
Don't meet job requirements	31,45	6	6	7	6
Other	22,96	8	8	8	7
Don't want to work	12,75	9	9	9	9

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

Table 5: Self-reported motivation for a facilitated receipt of benefits, marital status (East)

	All in %	Married Rank	Divorced Rank	Widowed Rank	Single Rank
No job offers by agency	93,40	1	1	1	1
Trusted in UB / UA until retirement	83,70	2	2	2	2
No other offers (further training etc.) by agency	53,08	3	3	4	5
Don't want to accept every job	36,20	4	4	6	3
Don't want to apply anytime / everywhere	31,71	5	5	5	4
Health not good enough	24,82	6	6	3	8
Other	18,81	7	8	8	6
Don't meet job requirements	16,31	8	7	7	7
Don't want to work	8,50	9	9	9	9

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

Table 6: Self-reported motivation for a facilitated receipt of benefits, skill level (East)

	All in %	Un-skilled Rank	Skilled Rank	Foremen etc. Rank	University degree Rank
No job offers by agency	93,43	1	1	1	1
Trusted in UB / UA until retirement	83,70	2	2	1	2
No other offers (further training etc.) by agency	55,08	4	3	3	3
Don't want to accept every job	36,21	6	4	5	4
Don't want to apply anytime / everywhere	31,71	5	5	4	5
Health not good enough	24,82	3	6	6	7
Other	18,81	7	7	7	6
Don't meet job requirements	16,31	8	8	7	8
Don't want to work	8,50	9	9	7	9

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

5.5 Factors Influencing Individual Decisions: A Logit Analysis

5.5.1 Dependent and Independent Variables

Since the motivation structure is relatively uniform for different socio-economic groups, we focus on the simple binary question which factors influence unemployed persons at age 58 and above to be chose the FRB.

For the selection of variables with a potential influence, we refer to the literature dealing with determinants of exit from work and entry into retirement.

Regional Labour Market Chances

In tight labour markets, early retirement occurs more often (Bangel 1993, Wübbeke 2005). Reasons are self-perceived low chances of older unemployed persons, as well as employer strategies to reduce staff via early retirement. Moreover, strategies of the responsible agencies might work in the same direction. In contrast, when many jobs are vacant, pressure on older workers to exit from work is lower.

As a proxy for regional labour market chances we use a dummy for East and West Germany. Despite growing heterogeneity within each part of the country,

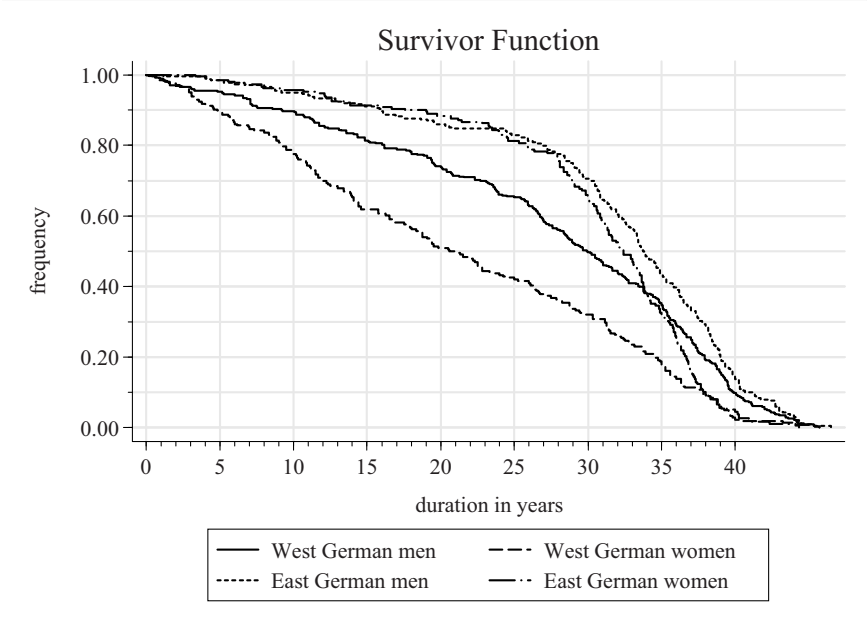
there are still remarkable differences between both parts, with unemployment in East Germany roughly twice as high as in West Germany.

H1: If the FRB is regarded as an equivalent to early retirement, we expect persons in East Germany to opt more often for a FRB than persons in West Germany due to different labour market chances.

However, if the FRB works as an instrument for persons who want to gain autonomy from the agency, no clear relationship can be derived. On one hand, it is plausible that under good labour market conditions for job seekers, the option of a FRB is used more often because persons want to decide without pressure. On the other hand it is also plausible that under these conditions the option is chosen less often, because the agencies are able to help into new jobs.

Gender

Figure 2: Duration of employment covered by social security contributions until beginning of 'decision period', East and West German men and women



Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

In our model, we do not include the regional dummy as a separate characteristic, but in conjunction with gender. This takes into account that East German men and women of the generation considered here have been quite similar in their careers, work attitudes and contribution to the household income, compared to West German men and women. As can be seen in Figure 2, the employment histories of East German men and women are very similar, while the employment histories of West German men and women differ clearly from each other.

H2: Men and women in East Germany differ less in their behaviour towards the FRB than men and women in West Germany.

Marital Status

The decision to retire depends on the employment status of the spouse; however, it depends for wives stronger on the employment status of their husbands than vice versa. Wives leave employment when their husbands retire, but husbands often remain employed when their wives retire. Within a male single earner household, the split for the wife before and after retirement is not clear-cut. Financial duties for other members of the family (children) tend to extend work life; persons with caring responsibilities tend to retire earlier (Allmendinger et al. 1992, Drobnič 2002).

H3: If the FRB works as an equivalent to early retirement, then we expect that married persons opt more often for a FRB than unmarried persons. As with *H1*, if the FRB works as an instrument for persons who want to gain autonomy from the agency while still looking for work, no clear hypothesis can be formed.

Skill Level and Occupational Status

Previous research about retirement processes point to the significance of the skill level for the moment to retire. According to these results, persons with higher skills remain longer in employment and retire later than persons with lower skills (cp. Radl 2007: 56f., Brussig et al. 2006a: 31, Büttner 2005: 9-12, Wübbeke 2005: 227f.). This reflects in part a lower risk of becoming unemployed and in part employment in tasks with lower health risks. At the same time, 'soft factors' might play a role. For instance, job satisfaction and identification with the job performed tend to grow with skill level, while work-related health risks tend to lower job satisfaction (Grotheer et al. 2003: 24-26). These arguments apply not only to the formal skill level – which might have been achieved quite a time ago – but to occupational status as well.

H4a: If the FRB works as a path to early retirement, we assume that persons with higher skills and higher occupational status – once they became unemployed – opt less often for the facilitated unemployment benefit than persons with lower skills and occupational status.

However, this relation might be valid only for a short period of unemployment. With enduring unemployment, individual human capital declines. Previous

skill and pay levels are not acknowledged as a justification to refuse job offers by the agency, long-term unemployment has negative signalling-effects on employers and there might be real loss in experience on behalf of long-term unemployed. These processes lead long-term unemployed persons off from their previous jobs and into low-skilled jobs. The individual decision to opt for the FRB might then be rather shaped by the individual readiness for job concessions.

H4b: If the FRB is an instrument for persons who want to gain autonomy from the agency while still looking for work, we expect that persons with high skills and from a high occupational status opt more often for the FRB.

Old Age Provisions

As indicator for old age provisions we use estimations of the persons interviewed. They were asked whether their expected income after retirement (based on the household level, i.e., including spouse etc.) would be roughly the same, significantly more or somewhat more or less than the household had at the moment of the interview. Persons who already received a pension at the moment the interview was conducted had to answer a modified question.

Persons who expect that their material situation will improve when they retire are under less pressure to find a new job. In contrast, inadequate old-age provisions are an incentive to find a new job even in later stages of the work life. However, if the previous pension contributions (and thus pension entitlements) are so low that they will be supplemented by further transfers (basic income support for older persons) then the motivation for a new job is probably low. An indicator for such a situation is the statement of the interviewee that their retirement income will be probably below the income they received at the time of the interview, when already drawing a means-tested basic income support.

H5a: Therefore, we expect an U-shaped relation: If the 'facilitated receipt of benefits' works as an early retirement scheme, then we expect that it is chosen more often by persons who anticipate a higher or lower retirement income compared to their current means. If the FRB is chosen by persons who seek autonomy from the agency, then we expect that the anticipation of a higher retirement income reduces the willingness for job concessions and therefore increases the tendency to make use of FRB (*H5b*).

An additional indicator for social security after retirement is the possession of a house or a flat and whether there is a mortgage. The possession of a (mortgage-free) house or flat should have the same influence as pension entitlements above the current income, the existence of a mortgage should work in the opposite direction (see *H5a, b*).

Other Control Variables

Other control variables are the year of birth, the kind of transfer income before unemployment benefit (UB) II, two indicators for immigrants ('not born in Germany' and 'mediocre or bad German language skills'), health status (degree of disability for handicapped persons), previous duration of employment, duration since the termination of the last regular job and the age at the time when the FRB was accessible for the first time (age 58, or, when unemployment started later, at later ages).

5.5.2. Regression Model and Results

Table 7 resumes the results of the Logit analysis represented as odds ratios. Values above 1 indicate an increased tendency to take up 'facilitated receipt of benefits' (FRB) compared to the respective referential category, values lower than 1 refer to a negative correlation.

First of all, we found out that some factors being looked at as possibly important proved to have no significant effect on the usage of the FRB. This concerns the difference between East and West German women and men as well as the vocational qualification, the marital status and – with one exception – the former occupational status. As a consequence, hypotheses *1* to *4b* are not supported by the empirical findings.

Instead, the status 'self employed' has a strong negative effect on the take-up of FRB. This result is in accordance with the results of a different study (Brussig et al. 2006a: 30), which pointed out that self-employed persons – especially men – receive their retirement pensions later than employed persons or persons not in the labour force. The low take-up rate of FRB points towards a high propensity to work in this group. A possible explanation might look as follows: Being closely related to competitiveness, an increased income and social prestige, self-employed persons might be linked to their profession in a way that makes them want to prolong their working life span.

A still stronger negative effect is caused by a lack of certainty in the use of the German language: Persons with low-level communication skills used the FRB to a minor degree. However, a migrational background ('not born in Germany') itself has no significant impact. We suppose a deficiency in communication between the persons receiving benefit and the respective agency caused by insufficient information material in relevant foreign languages, especially Turkish and Russian. Assuming that this hypothesis gives a proper explanation for the lower take-up rate of FRB in the group of language-deficient persons it underlines the outstanding importance of a high-quality policy of consultation and information carried out by the respective agencies.

Moreover persons who formerly received social assistance took up the FRB rarely. This result might be a consequence of their shorter period of decision, because former recipients of social assistance have been entitled to FRB only by the commencement of the Social Code II (see Section 2). Another reason for this may be found in the different perspectives of persons having received former social assistance and those who have drawn former unemployment assistance. Unlike the former social assistance and the new UB II the former unemployment assistance was status- and occupation-oriented and depended on the last regular income of the respective person. So the transformation of these two types of welfare payments into the new system of UB II may have meant for those persons having formerly received unemployment assistance a kind of social decline, because their status of a person being entitled to a worked-for assistance sank to the position of someone being supported by a social system. From the view of these persons the social system may not seem to pay a tribute to the individual achievements anymore but pay a flat-rate support not minding the individual working career. Under these circumstances persons receiving former unemployment assistance may be lured to claim FRB to adopt the more attractive and socially accepted role of a person in pre-retirement status.

Surprisingly there seems to be a negative correlation between the age at which a person could claim the FRB for the first time and the actual claim. The expected result would have been that persons who were already older when they started receiving benefits would use this option to a higher degree, because they had only a few years left before entering retirement. Instead the results pointed into the opposite direction. These unexpected findings might be explained by a selection effect: Assuming that pre-retirement-oriented persons retire earlier, then employment-orientied persons "survive" with an advancing age in our population.

By contrast, the results referring to the effect of old-age provisions on the decision whether to claim FRB or not are as expected: Interviewees trusting in an increased income when retired decided much more often to take the option of FRB, as well as owners of non-mortgaged houses or flats. In so far the results support hypothesis *5a*, admittedly with one exception: In the group of interviewees without having more than a mere chance of establishing more than a minimum standard of living, the expected increased claim rate for FRB could not be confirmed. Nevertheless, economic considerations as well as a feeling of social and material security have obviously a strong influence on the decision of when to retire.

Table 7: Determinants influencing individual decisions for a facilitated receipt of benefits

Covariates	Odds ratios	Standard errors
Social and demographic characteristics		
Place of residence and gender Reference category: West German man		
West German woman	0.96	0.24
East German man	0.94	0.23
East German woman	1.57	0.47
Reference category: birth cohort 1940-1942		
Cohort 1943-1945	0.86	0.28
Cohort 1946-1948	0.49**	0.16
Reference category: not married		
Married	1.37	0.27
Vocational qualification Reference category: dual system of vocational training, full-time vocational schools		
No or other vocational qualification	0.76	0.17
Master craftsman, technician	0.67	0.30
Non-university type higher education (Fach-hochschule)	1.48	0.61
University degree	0.64	0.25
Reference category: born in Germany		
Immigrant	0.82	0.24
Reference category: (very) good German language skills		
Medium or bad German language skills	0.36***	0.11
Health problems		
Reference category: not disabled		
Disabled	1.00	0.27
Severely disabled	0.68	0.20

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Work history	Odds ratios	Standard errors
Last occupational status before the receipt of benefits Reference category: medium occupational status (skilled worker, journeyman, foreman [Vorarbeiter],group leader, brigade leader, white-collar worker with skilled occupation) and unknown occupational status		
Low occupational status (unskilled or semi-skilled worker, white-collar worker with low-grade occupation)	0.92	0.20
High occupational status (master craftsman, foreman [Polier], white-collar worker with highly skilled occupation)	1.09	0.36
Self-employed (included self-employed farmers, liberal professions, freelance workers, contract workers, unpaid family workers)	0.38***	0.13
Duration of the current unemployment spell until the beginning of the period of entitlement to FRB Reference category: less than 6 months		
Duration of unemployment 6 - less than 12 months	0.63	0.32
Duration of unemployment 1 - less than 2 years	0.72	0.26
Duration of unemployment 2 - less than 5 years	1.09	0.33
Duration of unemployment 5 - less than 10 years	1.26	0.41
Duration of unemployment at least 10 years	0.87	0.34
Duration of employment in previous working life until the beginning of the period of entitlement to FRB Reference category: less than 5 years		
Duration of employment 5 - less than 15 years	3.75	3.45
Duration of employment 15 - less than 25 years	3.34	2.91
Duration of employment 25 - less than 35 years	2.33	1.97
Duration of employment 35 - less than 40 years	2.58	2.19
Duration of employment 40 - less than 45 years	3.47	3.08
Duration of employment at least 45 years	4.32	4.82

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Receipt of benefits	Odds ratios	Standard errors
Kind of received benefit before commencement of Social Code II Reference category: no or other benefit (especially unemployment assistance)		
Social assistance	0.39***	0.13
Age at the beginning of the period of entitlement to FRB Reference category: age 58		
Age 59	0.33***	0.12
Age 60	0.40**	0.18
Age 61	0.54	0.25
Age at least 62	0.12***	0.07
Old-age provisions		
Expected income in retirement (own income and partner's income) in comparison with the current income of the household Reference category: income in retirement will be approximately as high as current income		
Income in retirement will be much higher	2.08*	0.86
Income in retirement will be marginally higher	1.00	0.27
Income in retirement will be lower	0.83	0.22
No estimation of the income in retirement	0.65	0.25
Reference category: no property		
Owner of a mortgaged house or flat	0.84	0.26
Owner of a non-mortgaged house or flat	2.22**	0.77

Observations: 698

Pseudo R-squared (McFadden) = 0.21

* significant at 10%; ** significant at 5%; *** significant at 1%.

Source: IAB survey 'Life Situation and Social Protection in 2005' (QS I); calculations by the authors.

5.5.3 Discussion

The results of the Logit analysis corroborate the 'early retirement hypothesis' rather than the 'autonomy hypothesis': Whereas there was no evidence for the latter, some of the estimated effects pointed out that the potential users interpret the FRB primarily as early retirement and decide to claim or to refuse this option according to this interpretation. This view is supported by the fact that (former) self-employed persons who are supposed to be rather achievement-oriented and said to own a high propensity to work opted ceteris paribus less often for the FRB than all the other groups. A further hint towards the direction of the 'early retirement hypothesis' is given by the result that persons who assessed their expected material situation in retirement as particularly good and were therefore under less pressure to take up employment used the FRB to a considerably higher degree. Weak evidence for the 'early retirement hypothesis' also results from the negative effect of age as well as from the fact that persons who may have regarded the transition to UB II as social and financial decline (former recipients of unemployment assistance or unemployment benefit) have chosen the FRB more often than recipients of the former social assistance.

6. Summary and Conclusion

This paper discussed a special pathway from employment to retirement in Germany which is available for unemployed persons of age 58 and more. These persons are allowed to receive unemployment benefit (UB) or unemployment assistance even if they do not search actively for re-employment (which is usually a condition to receive these benefits). Due to this and some other relaxed conditions, this regulation is usually referred to 'receipt of benefits under facilitated conditions' or 'facilitated receipt of benefits' (FRB). Persons who choose this option do not count as unemployed. The only obligation for these persons is to apply for a deduction-free pension at the earliest possible moment. With the introduction of the basic income support (BIS), this regulation was extended to persons under the BIS-scheme ('Hartz IV') receiving UB II.

The FRB does not fit to both a general paradigm shift towards an activating labour market policy approach and a – largely successful – containment policy towards early retirement in Germany. Meanwhile, the regulation does not fit to the timing of retirement processes either: Up to the mid-1990s, it was possible to exit employment at age 57.3 into unemployment with UB entitlements of up to 32 months and to enter a deduction-free pension at the age of 60. Today, deduction-free old age pensions start at the age of 63 for severely disabled persons or at age 65 otherwise. Nevertheless, the regulation for a FRB was repeatedly renewed after its

implementation in German labour market policy in 1986. One explanation points to the interest of the Public Employment Services (PES) and the BIS-centres in concentrating on younger unemployed with better chances of re-employment.

The function of this regulation for the unemployed persons, however, is less clear. On the one hand, it might serve as a form of early retirement for unemployed persons; on the other hand, it might be seen as an opportunity to gain autonomy from integration strategies of PES- or BIS-agencies which became more and more restrictive ('activating') during the last years.

For the first time ever, our paper analyses socio-economic characteristics and self-reported motives of persons who opted for a FRB. Our analyses are restricted to persons within the tax-based UB II-scheme, where labour market policies are much more restrictive with fewer rights for unemployed persons than within the contribution-based UB-scheme. Furthermore, one can assume that recipients of UB II typically have not quit employment via an early retirement agreement with their firm, because in this case they normally would not have been forced to apply for UB II. Thus their orientation towards retirement is less clear compared to the recipients of UB. Therefore, our subgroup of persons who opted for a FRB is a better subgroup to test the 'early retirement'- vs. 'autonomy'-hypothesis than the subgroup of UB-claimants.

Our main results are:
First, the claimant rate among UB II-recipients is significant lower than among UB-claimants. Several reasons come to mind: a stronger interest of the PES in reducing visible unemployment compared to BIS-centres with a basic interest to reduce BIS-dependency. Moreover, and related to this, differences in information policies between agencies in both transfer systems might also account for differences in the acceptance of this regulation. Another reason might be the already mentioned exclusion of persons who have left the labour market via an early retirement agreement with their company.

Second, an analysis of self-reported motives shows that only a small minority of persons in the FRB actually did not want to work. So the withdrawal from the labour market via FRB seems to be first of all a resigned response to lacking job opportunities for older workers.

Third, according to our regression results, there is more support for the 'early retirement hypothesis' than for the 'autonomy hypothesis'. Hence, we conclude that in most cases the FRB works as one of the few surviving pathways of early retirement.

Would it, then, be necessary to abolish this regulation? The results indicate that the expiring of the 'facilitated receipt of benefits' itself won't increase the employment rate significantly unless the labour market chances for older unemployed will improve. But at any rate the abolition of the FRB could incite the agencies to in-

clude older unemployed in training and employment schemes to an increased extent and might thus help to improve the job prospects of the older unemployed.

Another aspect refers to the old age provisions of the recipients of UB II: The German Basic-income-support-scheme is strictly subsidiary, i.e., public support is given only if all other opportunities are exhausted, such as income of household members and individual savings. Without the shelter of the FRB, BIS-centres could theoretically enforce UB II-recipients to apply for a pension even if it is not deduction-free. For most people within the BIS-scheme, this would probably extend neediness into later life. While there are reasons to discuss a different design of a FRB at the end of working life, its optional character should be preserved and the obligation to apply for a pension only when a regular entry age is reached should be reinforced.

Epilogue

At the end of 2007, the facilitated receipt of benefits for unemployed persons at age 58 or more was not renewed. Since 2008, this option is not available for new entrants, while it remains effective for all persons already within the scheme. The optional facilitated receipt of benefit was replaced by a new regulation stating that all persons having received UB II for at least 12 month after the age of 58 without getting an offer for a job covered by social insurance are automatically not registered as unemployed. That is, the optional character of the earlier regulation is replaced by a regulation which leaves the decision whether to activate older unemployed to the BIS-centres. Recipients of UB II have to enter a pension not before age 63 (not optional). Since the regular pension entry age is at 65, a pension entry at age 63 comes with deductions of 7.2 % of their pension entitlements (see BT-Drs. 16/7460).

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Transition in the Italian Labour Market: Gender Differences Among the Over 50

Francesca Rinesi

1 Introduction

The European population age structure is dramatically changing. In the last decades there has been a rise in both the absolute number of old people and in their relative share of the total population. This well-known demographic change has deep socio-economic consequences, particularly concerning the labour supply and the general welfare regime. To encourage economic growth the European Union settles a common Employment Strategy and three main targets[1] that all European countries should achieve by 2010. Significant among these is a rise in the old workers employment rate. Italy has not only one of the highest dependency ratios among European countries but also a very low over 55 employment rate.

Labour market studies generally focus on the analysis of stock data, but the investigation of employment, unemployment and activity rates doesn't take into account the dynamic nature of this market. In other words, rates only give a static picture of the current situation, but completely ignore the flows' intensity of workers from one employment condition to another. Therefore, measuring the grade of labour market dynamicity[2] is fundamental for evaluating the quality of employment and even for addressing policy. In spite of these, there are only a few studies concerning the Italian labour market dynamicity, only a few of them focus solely on the behaviour of older workers[3].

This research has two objectives: the first is to estimate the employment state transition probabilities of older workers in Italy. The second is to investigate the impact of certain socio-demographic and economic variables on the retirement

1 The targets are: the employment rate, the female employment rate and employment rate of over 55% rise to 70%, above 60% and 50%, respectively (European Council, 2000; European Council, 2001).

2 We refer to a labour market as a dynamic one if workers change labour conditions (from employment to unemployment or out of the labour force and vice versa) quite often during their life course.

3 The more relevant studies that take into account explicitly the dynamic nature of the Italian labour market are Miniaci (1998), Testa (1999), Abissini and Discenza (2002), Finocchiaro (2005), Racioppi and Bambini (2006), Contini and Trivellato (2006). Only the first two of them are addressed to older workers.

decision. Meanwhile a special emphasis is placed on gender differences in the transition to retirement.

2. Theoretical Framework and Research Hypothesis

The labour market behaviour (particularly of older workers) is affected by a great number of demographic, economic and social variables. In particular there is one main reason why age is considered the most relevant demographic covariate that affects the transition to retirement. A worker can accede to the pension system provided that he or she has worked a minimum number of years and is above a certain age. Therefore, it is possible to hypothesise that the older a worker, the higher the probability that he or she can fill both requirements. Gender is another demographic characteristic affecting labour market behaviour. Women and men have different labour market participation patterns, especially in countries like Italy with a familistic welfare regime and where the male breadwinner model is still widespread. In this context women that work at age 50 represent a selected sample of all women. I want to test if there are gender differences in the retirement pattern even with reference to women that have shown a long-term attachment to the labour force over their life course. Finally, I want to measure the impact (if any) of marital status on the transition to retirement.

The labour supply, including individual decisions to exit from the labour market, is also affected by economic variables. In order to take into account the heterogeneity between workers, it is important, for instance, to consider whether a worker is self-employed or employed and the productive sector in which she or he works. The type of contract could be relevant too: part-time and full-time workers as well as low- and high-skilled employees might be expected to have different retirement behaviour. Finally, there are covariates that are neither demographic nor economic but help to understand the transition under study, including education and region of residence. There is evidence in Europe that higher educated individuals are more likely to be employed at older ages than their less educated counterparts (Eurostat 2002). There are at least two main reasons for that. The first refers to individual employability: Those who have spent more years in education have a higher human capital; secondly, the extra years of education result in a delayed entry into the labour market, postponing the age at which an individual accumulates the minimum number of years worked necessary to access his or her pension. This study examines the affect of education on the transition to retirement in detail. The last covariate I have introduced in the model is the geographic reference as it is well known that Italy is characterised by territorial-specific labour market patterns (North versus South).

3. Data Source and Methods

The Labour Force Survey used was provided by ISTAT, the Italian National Institute of Statistics. Part of the survey's sample has a longitudinal structure: With each subsequent year, half of the respondents remain in the survey sample so it is possible to study the transitions within labour conditions from time t to time t+1. I use the longitudinal part of the Labour Force Survey from the period 1992-1993 to 2002-2003.

The first target of this study is to measure the Italian labour market dynamicity for older workers. For this purpose I constructed the transition matrix from the employment condition to the other labour conditions (unemployment and out of the labour force). As a result, we estimate the transition probability which is the probability of an employed worker to be in a different/same labour condition one year later. As we have one decade's worth of data, we can compute ten different transition matrices (one for each year) and can estimate a trend of transition probabilities over time.

The elements we need to calculate a transition matrix are the information about the labour conditions at time t and time t+1. If we consider the three main labour conditions (employed, unemployed and not in labour force) we will have a square 3x3-matrix. Table 1 displays the transition matrix computed for the period 2002-2003. The main diagonal houses the persons who have the same labour condition at time t+1 as registered at time t, in the other cell entries we find those whose labour condition changes over the period[4]. The rows show the individuals working condition at time t, while the columns illustrate the final labour market condition at time t+1. From the absolute values contained in the matrix it is possible to compute the risk to change from one employment state to another. Adding these risks gives the overall probability of changing employment states.

The analysis of the transition matrices does not take into account the heterogeneity of the population under study. Therefore, the aim of the second part of this paper is to analyse the impact of certain socio-demographic and economic variables on the individual retirement decision. Since the dependent variable is dichotomous, I use a logistic regression model, where the response variable is equal to 1 if the respondents are employed at time t and have left the labour force in time t+1 and 0 otherwise. The explanatory covariates that are considered are: age (three classes: 50

4 When constructing transition matrices, we take into account only the initial and final individual labour condition In other words, it is not possible to consider possible changes in the intermediate period.

to 54, 55 to 59 and 60 to 64 years old), educational level[5] (high, medium and low), marital status (married and other conditions), area of residence (North, Centre and South of Italy), production sector (agriculture, industry and services), working hours (full-time and part-time) and employment status (high-skilled, low-skilled and self-employed workers).

Table 1: Transition matrix of the population aged 50 to 64 years old: period 2002-2003.

		Labour condition at time t+1			
		Employed	Unemployed	Not in the Labour Force	Total
Labour condition at time t	Employed	5947	36	480	6463
	Unemployed	55	140	93	288
	Not in the Labour Force	183	81	9071	9335
	Total	6185	257	9644	16086

Source: Own calculation on the longitudinal part of the Labour Force Survey (Istat).

Given the well-known gender differences in labour market behaviour, both the transition matrices and the logistic regression models were computed separately for males and females.

4. Results

Recent studies have shown that on the whole the Italian labour market is quite static. Flows within different labour conditions over a one year time period are scarce; it follows that the probability to persist in the same labour condition from one year to the next is high (Abissini et al. 2002, Contini et al. 2006).

5 The educational level is coded as low, medium and high, where the first stands for unfinished secondary school, the second for completed secondary studies and high for having obtained a university degree.

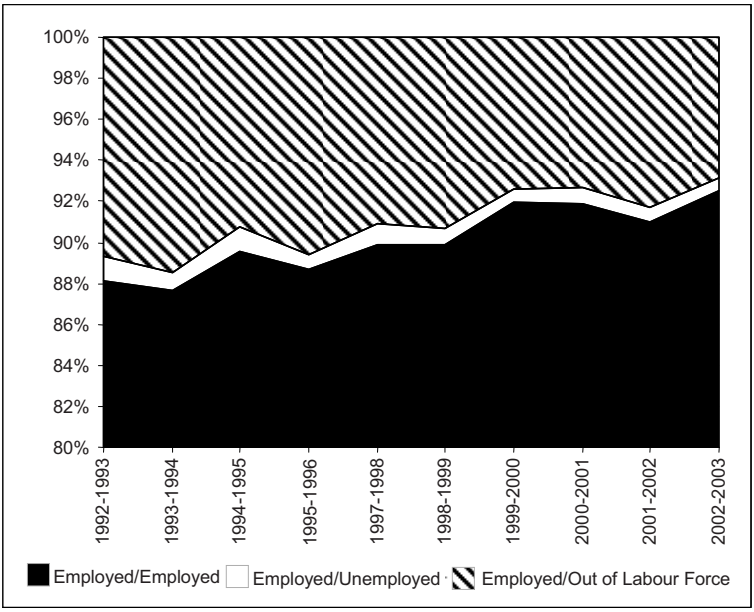
The older workers employment rate in Italy is low, particularly for females, especially if compared to other European countries[6]. At the same time the transition matrices that I have computed show that the older workers' labour market is not only very undynamic, but has also become even more static in the years under examination. 88% of the male workers from the beginning of the period were still employed one year later, but this percentage rose to 92% for the period 2002-2003. The share of employed that became unemployed was very low (less than 2%) and was almost constant throughout the period. As a consequence, the scarce outflows from the employment condition are mainly toward leaving the labour force.

Since there are strong gender differences in the labour market participation models the transitions matrices are computed separately for males and females for each year over a ten-year period. Figures 1 and 2 summarise the outflow trend from the employment state. The growth in the share of employed persons remaining in the state of employment was primarily due to the female labour force performance. At the beginning of the period considered (years 1992-1993) this share was lower than the one registered for males (respectively 83.7% and 88.1%). Yet by the end of the period it had increased to nearly the same level as observed in the male population. Thus in only ten years the gender difference regarding this indicator virtually disappeared.

The outflow from the employment to the unemployment condition concerns about only the 1% of old workers and occurs more frequently for male than for female workers. Moreover the risk to become unemployed was almost constant over time. Therefore, the growth in the probability to remain in the same labour state ran parallel to the reduced probability to leave the labour force from an employed state.

6 The Italian employment rate of workers aged 55 and over was 42.7% for males and 20.8% for females while the same rates for EU-15 member states were 53.1% and 35.4% respectively (Eurostat 2007).

Figure1: Transitions from the employment condition (%): males 50 to 64 years



Source: Own calculation on the longitudinal part of the Labour Force Survey (Istat).

A transition matrix is one of the most appropriate tools to measure the labour market dynamicity; however, it does not take into account the respondents' heterogeneity. In order to do so logistic regression models were computed where the dependent variable is the transition to retirement of employed workers aged 50 to 64 for the period 2002-2003. The exogenous explanatory variables included in the models[7] are: age, educational level, marital status, geographic residence, productive sector, working hours and employment status. I have chosen high-skilled male workers aged 50 to 54 years, married with a high educational level and a full-time contract in the services sector as reference profile.

7 I have run two different models, one for female and one for male respondents.

Figure 2: Transitions from the employment condition (%): females 50 to64 years

Source: Own calculat ion on the longitudinal part of the Labour Force Survey (Istat).

Table 2: Odds ratios (and level of significance) for the transition to retirement among male workers aged 50 to 64 years old in 2002-2003.

	Odds ratio	Level of significance
Age		
50-54	1	
55-59	2.801	***
60-64	3.722	***
Educational Level		
High	1	
Medium	2.140	**
Low	4.139	***
Marital Status		
Married	1	
Other	1.088	
Area of residence		
North	1	
Centre	0.627	**
South	0.461	***
Sector		
Agriculture	1.675	**
Industry	1.036	
Services	1	
Working Hours		
Full time	1	
Part time	2.738	***
Employment Status		
High skilled employee	1	
Low skilled employee	0.837	
Self-employed	0.379	***

*<0.1; **<0.05; ***<0.01.
Source: Own calculation on the longitudinal part of the Labour Force Survey (Istat).

Table 2 displays the results for male respondents. From the regression model computed it appears that age has a major influence on the retirement decision. The risk to exit from the labour market for those aged 55 to 59 years is almost three times the risk of the reference category and this difference is even bigger for those aged 60 or above. The educational level also appears to be a very important factor determining retirement patterns where the less educated workers have a significantly higher probability to retire than those with a university degree. This confirms the hypothesis made earlier. While the marital status did not have a significant impact on the retirement decision, economic reasons as well as the geographic location seem to play a large role. The risk of those who live in the central Italian regions (and even more for those in the South) is significantly lower than the risk for the reference category as well as those who work in services compared with individuals employed in agriculture. Finally the retirement risk increases for those who are part-time employed compared to the reference category, while risks are lower for both self-employed and low-skilled employed.

Table 3 shows the result of the logistic regression model computed for female workers. The age and educational level of the respondents also have a big impact on retirement decisions for female workers: The retirement risk increases with age and there is a significantly different behaviour only between the workers with a university degree and those with a low educational level, the latter having a 2.5 times higher risk to exit from the labour market than the former. Having a different marital or employment status didn't define specific retirement behaviour, nor did the area of residence. Instead the production sector and the number of working hours were paramount in the female transition. Women employed in agriculture have a significantly higher risk of experiencing the event under study, as well as those who work in industry. Finally, like for male respondents, the retirement risk is higher for female part-time workers then for full-time workers.

Table 3: Odds ratios (and level of significance) for the transition to retirement among female workers aged 50 to 64 years old in 2002-2003.

	Odds ratio	Level of significance
Age		
50-54	1	
55-59	2.896	***
60-64	5.396	***
Educational Level		
High	1	
Medium	1.851	
Low	2.506	**
Marital Status		
Married	1	
Other	0.739	
Area of residence		
North	1	
Centre	0.808	
South	1.260	
Sector		
Agriculture	2.269	***
Industry	1.694	**
Services	1	
Working Hours		
Full time	1	
Part time	1.721	**
Employment Status		
High skilled employee	1	
Low skilled employee	0.758	
Self-employed	0.794	

*<0.1; **<0.05; ***<0.01.
Source: Own calculation on the longitudinal part of the Labour Force Survey (Istat).

5. Conclusions

As a result of changing demographic conditions, active ageing could best facilitate economic growth. Therefore policymakers should look to set up country-specific targets and strategies. Within this reference frame, the study of labour market flow data seems very important in pointing out the main variables that have an influence on retirement decisions.

The Italian labour market was not very dynamic at the beginning of the observation period and became even less so by the end of the period considered. In the early 1990s, the risk for female workers to exit from the labour market was lower than for men, but in just a decade the gender differences almost disappeared. Nevertheless, the covariates that have a significant impact on the retirement decision remain rather different. Age and educational level are very important, both, for male and female respondents, but the variables mainly linked with the job type only significantly impact male behaviour. We can hypothesise that other social variables may affect female behaviour. In particular it would be interesting to determine the family's influence (i.e., investigate the role of the partner in joint decisions[8]) on retirement decisions, as well as the impact of health or family incomes or to introduce explicitly the social context by using multilevel models.

Finally, the retirement decision can not be linked exclusively to supply side elements. Behaviour is also deeply affected by exogenous factors such as national and international economic policy, the national pension system, trade union influences, the labour demand of old workers and the specific welfare regime.

8 Recent studies have highlighted that labour decisions are not only individual but also the outcome of a family decision (Henretta et al. 1983, Henretta et al, 1993, Blau et al. 1998, Gustman et al. 2000, Blossfeld et al. 2001, Bernasco 2003, Pienta 2003, An et al. 2004).

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