# ESF FORWARD LOOK Workshop – Charting new research agendas for ageing labour markets

**Dublin, Friday November 14, 2008**

**VENUE:** The ESRI, Whitaker Square, Sir John Rogerson's Quay, Dublin 2

## Programme

***WELCOME*** **(+ Coffee) (9.30 - 10.00)**

- Prof. Arthur van Soest (ESF Forward Look, Tilburg University), Prof. Brendan Whelan (ESF Forward Look, TILDA/ESRI)

**SESSION I – Understanding labour supply in ageing labour markets (10.00 - 11.45)**

***Chair:*** Prof. Bas Jacobs (Erasmus University Rotterdam)

- ***Labour supply and employment of older workers*** - Prof. Arthur van Soest (Tilburg University)
  - *Discussant*: Prof. Tim Callan (ESRI)
- ***Life-course events and later-life employment*** - Dr. Mark Bryan (University of Essex - ISER)
- ***Labour market incentives for the ageing workforce*** - Dr. Brenda Gannon (NUI Galway)

**Coffee Break (11.45 – 12.00)**

**SESSION II – Human capital investment in ageing labour markets (12.00 – 13.15)**

***Chair:*** Prof. Brendan Whelan (TILDA/ESRI)

- ***Human Capital, Retirement and Pension Saving*** - Prof. Bas Jacobs (Erasmus University Rotterdam)
  - *Discussant*: Prof. Elsa Fornero (University of Turin, CeRP)
- ***Age specific dynamic human capital investment. The role of labour supply and demand*** – Dr. Tsvetomir Tsachev (Institute of Mathematics and Informatics, Bulgarian Academy of Sciences)

**Lunch (13.15 – 14.00)**

**SESSION III – Understanding labour demand in ageing labour markets (14.00 - 15.45)**

***Chair:*** Prof. Arthur van Soest (Tilburg University)

- ***The Demand for Older Workers*** - Prof. Brendan Whelan (TILDA/ESRI), Amilcar Moreira (TILDA), Asghar Zaidi (OECD)
  - *Discussant*: Dr. Peter Riach (IZA Bonn)
- ***Measuring the Work Ability of the Ageing Workforce*** - Dr. Derek Ross (Trinity College Dublin)
- ***An Experimental Investigation of Age Discrimination in Labour Markets*** - Dr. Judy Rich (University of Portsmouth)

**Coffee Break (15.45 – 16.00)**

**CLOSING SESSION (16.00 - 16.30)**

- ***Future research on ageing labour markets. A needs assessment*** - Prof. Brendan Whelan (TILDA/ESRI)

# Labour Supply and Employment of Older Workers

**Arthur van Soest**

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*Preliminary version, please do not quote*

November 2008

**Abstract**

This paper is part of the ESF Forward Look project "Ageing, Pensions and Health." It gives an overview of the current state of the literature on labour supply and retirement behaviour of older workers, focusing on European countries. It also sketches gaps in knowledge, opportunities for research, and the research infrastructure needed to make such research successful.

# 1. Introduction

A key policy concern of European policy makers is how to raise the labour-force participation of elderly workers. Retirement and labour supply decisions of older workers are core issues of micro-economic research, using standard life-cycle models or incorporating behavioural features. There is consensus among economists that economic factors like the generosity of early retirement benefits and pensions play an important role, but in addition, psychological and social factors are crucial, like quality of work, social networks, labour market status and retirement decisions of family members and peer groups. Also health plays a major role, e.g. through work disability, morbidity or expected longevity. Public policy affects the economic environment under which labour supply decisions are made, e.g. through eligibility and level of state pensions and through taxation of occupational and private pension savings. On the other hand, because labour supply of older workers and retirement decisions affect the sustainability of the pension system and the macro-economic supply of labour, they in turn also have obvious implications for public policy.

It seems obvious that labour force participation and labour supply decisions are not the only factors driving employment: demand factors also play a crucial role. Demand side adjustments will be necessary to accommodate increased supply of older workers, and progress can be made on, for example, hiring policies, attitudes towards immigrant workers, training of older workers, use of alternative exit routes by employers and employees, accommodating workers with a health problem, and creating more opportunities for gradual retirement. These adjustments may require changes in labour-market institutions with substantial macro-economic implications. Still, this paper focuses on the supply side – the demand for labour of older workers and (investing in) their productivity are covered in companion papers.

In this paper, we first sketch the background and policy questions relevant for this topic (section 2). We then present an overview of the existing literature on the determinants of labour force participation and labour supply decisions (section 3). In section 4, we discuss remaining gaps in knowledge and research challenges. Section 5

discusses what is needed to face the research challenges identified in section 4. Section 6 concludes.

## 2. Background and Policy Questions

In most OECD countries, the population is ageing and will continue to do so over the next few decades. Keeping labour supply and retirement patterns constant, this will reduce aggregate labour supply and will increase the ratio of economically inactive and economically active people, the so-called dependency ratio. This is expected to have negative macro-economic consequences, leading, in the end, to a lower average living standard, either through lower (state or occupational) pensions or through higher taxes or (pension) premiums. Moreover, there are other, non-economic, reasons why increasing labour force participation at older ages is desirable. For example, increasing the number of labour force participants can be seen as a way to increase social cohesion (Burniaux, Duval and Jaumotte, 2004), it reduces old age poverty and increases the economic welfare of the elderly, and there is even some evidence that at the individual level, "active ageing" by keeping at work increases well-being (Hartlapp and Schmid, 2008) and helps in maintaining cognitive skills (Bonsang et al., 2007). As a consequence, policies aimed at increasing labour force participation and hours worked by older people have been discussed and introduced in many countries (see, e.g., Disney, 2001).

Tables 1 and 2, taken from Kalwij and Vermeulen (2008), are based upon harmonized data on the 50+ populations in eleven European countries from the Survey of Health, Ageing and Retirement in Europe (SHARE), drawn in 2004 (see also Section 5). They reveal large variation in labour force participation rates for men as well as women, particularly in the age range just before the common standard retirement age of 65. For men in the age group 60-64, the participation rates range from 7.9% in France and 16.8% in Austria to 67.8% in Sweden and 72.0% in Switzerland. For women in the same age group, the range is similarly large – from 7.6% in Belgium and 8.0% in Italy to 62.4% in Sweden and 47.8% in Switzerland. Hartlapp and and Schmid (2008) present a similar rang for participation in the age group 55-64 in a different set of European countries, and point at the large correlation between participation rates of men and women.

There are many potential explanations for these large differences across countries. One respect in which countries clearly differ is the institutional arrangements concerning (early) retirement, the generosity of state and occupational pensions, and, in particular, how the levels of these benefits vary as a function of the age at which people stop working and/or start claiming them. The fact that financial incentives are important leads to several potential policies to increase labour force participation and postpone retirement. Kapteyn and Andreyeva (2008) summarize the most important ones:

- Adjust pension benefits so that the additional annual pension benefit given for each extra year of work is a fair compensation for postponing pension benefit receipt and for the extra contribution made (in technical terms: make sure that pensions are actuarially fair and the net present value of pension accrual is positive);
- Increase the eligibility ages for pension benefits (e.g., index the eligibility age by life expectancy).
- Replace Defined Benefit pensions by Defined Contribution pensions, so that benefits are a function of one's contribution (and of the return on investment). This automatically leads to actuarially fair adjustment of benefits when retirement is postponed.

Economists have focused on the role of these financial incentives. There seems to be common agreement among them that financial incentives are indeed important, but cannot explain all features of retirement patterns, leaving a substantial role for other factors (cf., e.g., Lumsdaine and Mitchell, 1999). The next section provides an overview of the existing literature. One of the non-economic factors recently emphasized is health. According to Kapteyn and Andreyeva (2008), the importance of health as a determinant of labour supply is implies a role not only for health policy, but also for educational policy, since theoretical and empirical work both suggest that the health capital of individuals with less human capital depreciates faster than that of individuals with more human capital. They list the following policy options that are unrelated to financial incentives:

- Improve education in order to raise human capital;

- Make jobs healthier;
- Promote healthy behaviour (diet, physical activity, and smoking behavior).

While the literature has mainly focused on labour force participation and retirement, the extensive margin of labour supply, the intensive margin is certainly also relevant. The central concept in this context is gradual retirement (see, e.g., Reday-Mulvay, 2000) a step-wise transition from full-time full-effort employment (usually, the "career job") to complete retirement, typically involving a period of part-time work but sometimes also full-time work of a different nature, requiring less effort (a "bridge job", see, e.g., Ruhm, 1990). Gradual retirement can have two forms: without change of employer (phased retirement) or also involving a change of employer (partial retirement). While the latter seems more popular in the US, the former seems the more common way to gradually retire in Europe, where job mobility among older workers is much smaller (Kantarci and van Soest, 2008).

Table 3, taken from Kantarci and van Soest (2008), is based upon several waves of the European Community Household Panel. In almost all cases, part-time employment is more prevalent in the older age category 51-65 than in the younger category 35-50, suggesting that workers reduce their work effort later in life. There is huge variation in the prevalence of part-time work across countries, for both sexes and in both age groups. In the Netherlands, part-time work among older men and among women in both age groups is much higher than in most other countries. Again, institutional differences may play a large role in explaining these differences, for example concerning the possibilities of combining part-time work and receiving a pension. Many European countries have taken policy measures to stimulate gradual retirement, first with the purpose to create more jobs for younger workers and later with the aim to increase participation of older workers (cf. Belloni et al., 2006). Making gradual retirement easier has two opposite effects on labour supply – people who otherwise would keep working full-time may reduce their hours of work, while others will keep working part-time instead of retiring completely. For macro-economic policy, the most important question seems to be which of the two effects dominates and what will be the net effect on total labour supply.

To illustrate that labour supply considerations are not the only relevant factors for actual hours worked, Figures 1 and 2 (taken from Kantarci and van Soest, 2008) compares the fractions of male and female workers in the Netherlands who actually work part-time with the fraction of workers whose desired number of working hours per week implies that they would prefer to work part-time rather than full-time (keeping the hourly wage rate constant). The fact that the latter fractions are larger than the former suggests that a substantial number of people faces hours constraints and cannot simply reduce hours of work on their current job. This applies to younger workers as well as to older workers for whom part-time work would be a form of gradual retirement. The figures suggest that access to gradual retirement is limited in the Netherlands, the country where part-time jobs are quite common relative to most other European countries, implying that looking at labour supply alone is certainly not enough to design effective public policies.

All this implies a number of relevant research questions relevant for public policy, including the following:

- What is the role of financial incentives in explaining labour force participation of older age groups and differences in participation rates across European countries?
- Which other factors can explain labour force participation of older age groups? What are the roles of, for example, work limiting health problems, family considerations such as labour force participation of the spouse or responsibilities for children, grandchildren, or elderly parents, cultural factors and reference group effects, job characteristics and satisfaction with work?
- How effective are the current national pension policies in maximizing labour force participation of older age groups? Can we design additional policies that work through other channels than financial incentives, such as improving work conditions for people with work disabilities?
- How desirable is gradual retirement, from the point of view of workers as well as employers? And how does gradual retirement affect the macro-economic supply of labour?

- What is the interplay between supply and demand factors that drive participation, employment, desired hours, and actual hours? Are supply policies sufficient, or should we also think of policies focused on employers, on enhancing productivity of older workers, or on creating an appropriate institutional environment?
- What are the consequences of increasing labour supply of older workers for the economy as a whole, for the economic and non-economic well-being of the older population, for poverty among the elderly, etc. etc.?

# 3. Existing Literature[1]

Following the overview of Kapteyn and Andreyeva (2008), at least three explanations for the large variation in retirement patterns across countries have been given. The first is financial incentives, emphasized by the work of Gruber and Wise and a group of researchers who did country specific studies using a harmonized methodology (Gruber and Wise, 1999, 2004, 2007) as well as many other studies (e.g., Duval, 2003, or Belloni et al., 2006). The Gruber and Wise projects evaluate the link between provisions of social security programs and national employment patterns. Another stream of research on economic rewards and labour force participation is based upon cross-country variation in marginal tax rates (Prescott 2004; Davis and Henrekson 2004). The key feature of all studies focusing on the financial explanation of differential labour force participation across countries is that they consider the substitution effect (a higher reward for working longer raises the price of leisure around the retirement age, and thus reduces the demand for leisure and increases labour supply) as the dominant factor in shaping choices of the representative individual in the income-leisure trade-off.

A second explanation points at differences in preferences or culture that lead people across countries to make different choices between income and leisure. Blanchard (2004) shows that most of the decrease in hours worked per capita in Europe over the past decades is due to a decline in hours worked per full-time worker rather than an increase in unemployment or a reduction of the participation rate. Since there has been no

[1] This section strongly hinges on an excellent recent literature review in Kapteyn and Andreyeva (2008).

general change in income taxes that can explain this, the most likely explanations are a negative income effect or a shift in preferences towards a larger marginal utility of leisure.

A third explanation of different employment rates across countries points at the role of institutions, including the power of unions. Labour market regulations advocated by unions in declining European industries, such as work sharing policies, led to a reduction in hours worked, aimed at addressing the unemployment problem. According to Alesina et al. (2005), European unions that pursued policies like "work less, work all" and similar labour market regulations are the primary contributor to much lower working hours per person in Europe than in the U.S. The work sharing policy has not raised employment but has influenced leisure patterns in society through a social multiplier effect. The increasing returns to leisure in the number of people enjoying more work-off hours may explain why Europeans today work much less than Americans.

A discussion of retirement patterns also has to consider the role of health. Retired individuals often give poor health as the primary reason for why they exited the labour force. At first sight this is paradoxical, as health seems to have improved substantially over the last three or four decades, while at the same people have retired at increasingly younger ages. Galama et al. (2008) introduce an extension of the Grossman (1972) health production model to explain this paradox.

**Financial Incentives**

Numerous studies have documented that until recently workers were leaving the labour force at increasingly younger ages (Gruber and Wise, 1999), while at the same time real earnings have risen and the average length of the working year has declined. Increased private income and higher public spending can maintain or even raise consumption levels at reduced hours of work. In a static neoclassical model of labour supply this happens if leisure is a normal good and the income effect of higher real wages dominates the substitution effect. In reality, there may be considerable heterogeneity across individuals with some opting for more leisure and others favouring more consumption. Furthermore, incentives faced by individuals are much more complicated

than as represented by a simple leisure-consumption trade-off with a linear budget constraint.

One of the most well-known examples of the literature on financial incentives and retirement is a set of studies directed by Jonathan Gruber and David Wise (1999, 2004, 2005, 2007). This stream of research provides comparable data on social security systems and labour force participation patterns in twelve OECD countries and investigates the links between the two. Using the same analytic format for each country, the studies describe social security incentives to retire and document their strong relationship with the proportion of older people out of the labour force. The standardized approach allows for comparison of retirement incentives across countries in addition to country-specific analysis. The Gruber-Wise studies emphasize that social security programs often create strong incentives to leave the labour force. In particular, they find that: (1) There is close correspondence between the eligibility age for early and normal retirement benefits and departure from the labour force; (2) There is often a substantial tax burden on working after the social security early retirement age; (3) Disability and unemployment programs in some countries are effective mechanisms to provide (quasi early retirement) benefits before the early (or standard) retirement age, and (4) The large cross-country variation in the tax burden on work affects the incentives to withdraw from the labour force and the retirement patterns (Gruber and Wise 1999, 2005).

Using micro-simulation models of retirement incentives, the Gruber and Wise studies estimate the effect of one year of continued work on future benefits under social security systems with varying incentives for early retirement. The results show that in all countries the retirement incentives inherent in most social security programs are strongly linked to withdrawal from the labour force. The size of the effect varies across countries, but the effects are always substantial (Gruber and Wise 2004, 2005).

The Gruber-Wise studies also consider the fiscal implications of program reforms to extend labour supply of older workers, such as increasing the eligibility age for early retirement benefits. The estimated financial consequences of reforms in social security provisions on net program costs are substantial, varying between 20% and 40% of current programme costs (Gruber and Wise 2005).

The role of economic rewards in determining retirement behavior is also documented in a stream of cross-country studies that consider the effect of taxes on market work activity. For example, Prescott (2004) argues that most of the differences in labour supply over time and across the G-7 countries are due to differences in tax systems, in particular the effective marginal tax rates on labour income. Using a panel of OECD countries, Davis and Henrekson (2004) find large supply responses to taxes and estimate that higher tax rates on labour income and consumption expenditures lead to less work in the market sector, an increase in informal household work, a larger underground economy, and lower value added and employment in industries which employ low wage unskilled workers. In line with this, Olovsson (2004) finds a primary role of taxes in explaining differences in labour supply between Sweden and the U.S. in a study that also incorporates non-market production activity.

On the other hand, Alesina et al. (2005) concludes that if taxes were the only differential between Europe and the U.S., labour supply elasticities would have to be much higher than those observed empirically. Nickell (2004) finds that an increase of 10 percentage points in payroll, income and consumption tax rates could reduce overall labour market input by about 2% of the working age population. This attributes the key role in labour force participation disparities across countries to social security systems supporting non-working groups, including the disabled, unemployed and early retirees.

Complementing the Gruber and Wise studies, Duval (2003) analyzed the effects of old-age pension systems and other social transfer programs on the retirement behavior of male workers in 22 OECD countries, comparing the sensitivity of the retirement decision to financial incentives and, in particular, the changes in present value of net future income streams induced by postponing labour market exit (the implicit tax on continued work). Overall, implicit taxes vary substantially, and they are more important in most of Continental Europe than in Japan, English-speaking, or Nordic countries. For example, the range of implicit tax rates on continued work over the next 5 years at age 65 is above 70% in France, Spain and Italy, but less than 20% in the US, Canada and Japan. Based on descriptive data and econometric estimates, Duval concludes that implicit taxes on continued work have notable effects on the withdrawal of older men from the labour force.

A comparative analysis of retirement incentives in pension policies with cross-nationally comparable indicators for evaluating public pension policies across 30 OECD countries is presented in OECD (2005; 2007). These studies not only develop comprehensive indicators characterizing pension systems across countries, but also provide case studies for each OECD country with a summary of the pension system and detailed country-specific results. Another cross-national study of economic rewards and retirement is Keenay and Whitehouse (2003), analyzing the personal tax treatment of older adults and its implications for retirement patterns in nine OECD countries. The value of tax concessions and their links to income vary across countries, and on average, the tax burden is 10 percentage points lower for pensioners than for workers. The authors conclude that the role of tax and social security contributions in shaping retirement incentives is important in cross-country comparisons of financial motives to retire, particularly due to its variation across countries.

Finally, another explanation for the employment gap between Americans and Europeans is the larger extent to which home production can be substituted with services available in the labour market (Freeman and Schettkat 2001). In this view, supported with time use data, the total amount of formal plus informal (household) work is the same for Europeans and Americans. The lower tax wedge and wider wage dispersion in the U.S. makes market work relatively more attractive in the US than in Europe. A choice in favour of market work vs. home production is more rewarding for high-wage earners whose share is larger among women in the U.S. The higher opportunity cost of time induces more women in the US to choose market work instead of home production.

Altogether, there is little doubt that financial incentives matter a great deal in explaining differences across countries in employment rates and retirement patterns. Studies differ however in which part of the total observed variation in labour supply they ascribe to purely financial incentives.

**Preferences**

Part of the labour supply literature explains international differences in employment from long-standing cultural norms that form attitudes toward work.

Different preferences, social and cultural perceptions imply different utility functions in Europe and the US. Blanchard (2004) argues that with roughly similar productivity levels in the two regions, stronger preferences for more leisure vis-à-vis income in Europe can account for the observed reduction in hours worked among European workers over the last 30 years. Decomposing the change in hours worked over the last decades into the changes in hours per worker, employment rates, and participation rates, he finds that most of the reduction in hours worked per capita in Europe reflects a decline in hours worked per full-time worker rather than an increase in unemployment or a fall in labour force participation. His empirical analysis leads to the conclusion that the decline in hours worked is mainly due to a preference shift rather than an effect of taxes.

**Institutional Arrangements**

Alesina et al. (2005) explain the decrease in hours worked in Europe and the U.S.-Europe employment gap from labour market regulations imposed by European unions in the 1970s and 1980s. Union density and power is stronger in Europe than in the U.S., which can be explained from political conditions (e.g., American federalism vs. proportional representation, which is more common in Europe). The importance of unionization and labour market regulation increased markedly with the structural shocks of the 1970s and 1980s (Blanchard 2004). Under the slogan "work less, work all", unions in declining European industries advocated a policy of work sharing that sought to reduce work hours to increase employment (see, e.g., Estevão and Sá, 2008, for the French 35-hour workweek reform). The advocacy of powerful unions was essential to implementing a number of labour market regulations, including union contracts and labour regulation pension laws, but these policies have not achieved their goal of lower unemployment (Kapteyn et al., 2004).

Using a panel of countries, Alesina et al. (2005) find that the effects of taxes on labour supply disappear when they control for unionization or labour market regulation. They show that the effect of union status on vacation and hours worked across US states is at least as large as the impact of taxes. Overall, they find convincing evidence for a dominant role of labour market regulation and unionization in explaining why Europeans

today work much less than Americans. For example, legally mandated holidays account for at least 80% of the gap in weeks worked between Europe and the U.S., and 30% of the differential in total labour supply between the two regions. Another potential factor explaining a decrease in hours worked in Europe is the effect of generous European pension systems which reduces participation amongst older workers.

The policies endorsed by unions in Europe may have had an indirect effect on labour supply through a social multiplier on the marginal utility of leisure (Glaeser et al. 2003). People enjoy leisure more when leisure of their friends, relatives and social groups increase. This social multiplier hypothesis can explain why Europeans have a stronger preference for leisure and prefer to exploit their increased productivity to increase leisure and reduce hours of work.

**Health and Retirement**

There is little doubt that individuals in developed countries are healthier than in the past, as illustrated for instance by the secular trends in life expectancy. At the same time there is a tendency to retire at earlier ages, as discussed above. Paradoxically, when asked about reasons for retirement, a frequently encountered answer is bad health. Although failing health is a plausible reason to retire, it is hard to believe that work conditions nowadays are more strenuous than they were in the past. Moreover, since health in the population is improving, one would expect that the role of health in retirement decisions is falling over time.

Several mechanisms can create a link between health and retirement. Failing health may lead one to retire (e.g., Disney et al., 2006; Kalwij and Vermeulen, 2008). If this were the only mechanism at play then one would expect the increase in population health to be accompanied by an upward trend in retirement ages. Moreover, retirement status may have a (positive or negative) influence on health. Retirement may be beneficial because one is relieved of the work stress and effort. On the other hand, retirement is a major life event, which in itself creates stress and may reduce health. Existing studies often find a negative effect of retirement on, in particular, mental health (e.g., Bonsang et al., 2007).

Within economics, an obvious framework for studying the relation between health and retirement is the well-known Grossman model (Grossman 1972) in which individuals derive utility from consumption and health, but where health also influences earnings. Over the years several extensions of this model have been proposed. To address the paradox mentioned above, Wolfe (1985) and Galama et al. (2008) introduce variants of the basic Grossman model that include a retirement decision. In this framework a couple of implications emerge. First, individuals with lower human capital (and hence lower earnings capacity) have fewer resources to invest in health so that their health deteriorates faster, implying that health will be positively associated with income and education (Case and Deaton 2005). A higher earnings capacity also induces people to work longer, as has been observed in many studies. Yet, at the same time secular improvements in health have an income effect that reduces work effort and hence explains trends in early retirement.

# 4. Research Challenges

In this section we identify a number of research questions on which progress can in principle be made in the near future:

- The effects of pension reforms on early retirement in Europe
- Preferences and opportunities for gradual retirement
- The role of health and the causal pathways between health and socio-economic status
- The interaction of economic and non-economic determinants of retirement
- The interplay of employer preferences, employee preferences, job characteristics, job satisfaction, and retirement
- Alternative exit routes: unemployment and disability

**Pension reforms**

Since the early 1990s, many countries have engaged in intense reforms of their pension systems, focusing on reducing the generosity of early retirement benefits and changing the incentives to make early retirement less attractive through a system of an actuarially fair compensation of working longer. Reforms varied across countries, but often involved increasing the eligibility age (and in some cases equalizing eligibility ages for men and women), increasing incentives for continuing work (e.g., bonuses for retirement after the normal pension age), changes in the benefits calculation (e.g., extending the period of earnings measurement or changes in qualifying conditions), and replacing Defined Benefit (DB) schemes by Defined Contribution (DC) or mixed schemes, changes in the indexation of pensions (e.g., moving towards partial or full indexation to prices), and changes in pension contribution rates (see, e.g., OECD 2007).

Country specific studies have exploited some of the reforms of the systems of state pensions in specific countries to analyze whether retirement decisions are sensitive to the financial incentives, such as the level of the benefits and the "accrual" in the benefit level due to additional year of work. Still, substantial progress can be made by rigorously exploiting the variation in a number of countries simultaneously, learning from the variation over time within and between countries. The Gruber and Wise studies referred to above are an interesting attempt in that direction, using similar stylized models to estimate the effects of financial incentives in separate countries. The availability of new, harmonized, data such as SHARE creates potential for further progress.

**Gradual retirement**

While most employees seem to have a strong aversion against working full-time after the normal retirement age, recent surveys suggest that many might be interested in a part-time job. Introducing more opportunities for gradual retirement may therefore be an attractive way to increase labour force participation of older age groups. Research on gradual retirement has been done, but mainly on the U.S. and of a rather descriptive nature. European policies aimed at stimulating gradual retirement have been described in several papers, but rigorous, structural, modelling is lacking. The crucial question is

whether the positive effect of creating part-time work opportunities on labour force participation exceeds the negative effect on labour supply of those who would keep working full-time in absence of gradual retirement possibilities. Particularly since not everyone has yet access to attractive forms of gradual retirement with a combination of part-time earnings and a partial pension, this questions requires structural modelling in the spirit of, for example, Stock and Wise (1990), Gustman and Steinmeier (1986), or Blau (1994). These models can in principle be extended to incorporate gradual retirement, for example by introducing part-time work as an additional labour market status.

**The role of health**

The theoretical work on the extension of the Grossman model to explain the interrelations of health and retirement of Galama et al. (2008) seems very promising, since it can offer plausible explanations for various stylized facts. Still, this framework not only remains to be developed to its full extent, it also needs to be transformed into an empirical model that can be estimated and rigorously tested. This is an important research challenge for the next couple of years, also since it can give new insights in the often studied association between health and socio-economic status (cf., e.g., Smith, 2007). To understand the causal mechanisms at work more fully, it also seems useful to go into more detail and disaggregate, e.g. by distinguishing between mental and physical health, by explicitly incorporating job characteristics such as stress and physical effort, and by making the role of health insurance explicit. Moreover, while the effect of health on labour market outcomes can be immediate, the reverse pathway, the effect of economic and social events on health, may take a much longer time to become effective (cf., e.g., Van den Berg, Lindeboom and Portrait, 2006). This suggests that it is worthwhile to study health and retirement in a long-term perspective, requiring, for example, information on socio-economic events and health shocks that happened much earlier in life.

**Economic and non-economic determinants**

While existing studies have addressed both economic and non-economic determinants, they typically consider one type of factors without controlling for the other factors. In principle, this may lead to omitted variable biases in the results if the various factors are correlated – and it seems obvious that they often are correlated. Moreover, it seems interesting to analyze the relative contribution of the various factors, something which also has hardly been done. Now that data sets are becoming available with observed variation in pension entitlements, health, social participation, and family background and circumstances on the same respondents, an analysis that simultaneously incorporates all the main factors of retirement behaviour seems to become feasible.

**Demand and supply**

As explained in section 1, the fact that this paper studies the supply side of the labour market by no means should imply that the demand side is not important. On the contrary, employer attitudes (and the way they are perceived by the employees) are important for the trade offs between leisure and income that drive retirement behaviour, since they have an important effect on job characteristics, job satisfaction, and the attitude towards continuing to work, which are all known determinants of the labour force participation decision. The ideal model should account for these factors, for example by incorporating information on the employer and the firm, either by matching firm and employee data, or by asking survey questions to employees about their employers (or both). We expect that some progress can be made in this respect, although an obvious complication is the fact that the employer is a choice of the employee, and although mobility at an older age is smaller in Europe than in the US, older workers can select their employer taking account of their own retirement preferences.

**Other Determinants of Retirement and Labour Supply**

Another factor that plays a role is the nature of the job and the individuals' attitudes towards their work. Job characteristics and job satisfaction are important

determinants of commitment to work and affect the willingness to keep working. Hayward et al. (1989) use indexes for "substantive complexity", "manipulative skill", and "social skill", constructed using factor analysis on the basis of a large number of survey items.

The US literature concludes that retirement of couples is based upon joint decision making, thus emphasizing the role of the spouse. See, for example, Blau (1997, 1998) and Gustmann and Steinmeier (2000, 2004) for economic models of decision making of couples and Henretta et al. (1993) for a "Family Organizational Economy" model, where the joint decision making process is driven by variables like the length of the marriage, the number and birth spacing of the children, and how much the wife worked when the children were young. More generally, family circumstances and family networks may play an important role, for example through informal care for elderly parents or grandchildren (Currie and Madrian, 1999; Heitmueller, 2007). The role of social networks, not necessarily the family, as reference group effects is discussed in, e.g., Woittiez and Kapteyn (1998) and Aronsson, Blomquist and Sacklén (1999).

**Alternative exit routes**

There are several ways in which older workers leave the labour market and make the transition from full-time work to complete retirement. Working full-time until some retirement age and then stop working to enjoy a retirement pension (also called "cliff edge" retirement; see Vickerstaff, Cox and Keen, 2003) is just one of them. Gradual retirement in the form of either a bridge job at another employer, or in self-employment, or as an employee at the same employer but with reduced hours or an adjusted task requiring less effort is a second way to make the transition. The labour market exit may also be non-monotonic, in the sense that retired partially retired workers sometimes return to work, or workers in gradual retirement working part-time return to their old full-time job ("reverse retirement"; see, e.g., Maestas, 2007).

Moreover, workers can spend some time in unemployment or on disability benefits before retiring. Unemployment and disability have been seen as substitutes for early retirement that can be attractive for the employer as well as the employee, although

the evidence seems inconclusive. Kerkhofs, Lindeboom and Theeuwes (1999) find some evidence of substitution in the Netherlands, while Riphahn (1999) finds no substitution in Germany. Dahl, Nilsen and Vaage (2000) find similar results for Norway. Most retirement models, however, ignore the alternative exit routes, making some exogeneity assumption that justifies dropping observations with a disability or unemployment spell from the sample. A promising exception is Heyma (2004), who builds the choice between various exit routes (all seen as absorbing states) into a single structural dynamic model. With adequate data following the same individuals over a long period of time and with enough detail on financial incentives, health, and demand side constraints, it seems promising to follow this research strategy and build more realistic models with several exit routes, giving more insight in the determinants of labour force participation and its alternatives.

# 5. Research Needs

The main conditions for research progress in the next five years in the field of ageing, pensions and health are related to data collection, making data available to the research community, and exchange of knowledge between countries and disciplines.

### Data Collection

Although substantial progress has been made in the past five years, particularly with the beginning of SHARE, the Survey of Health, Ageing and Retirement in Europe, a lot remains to be done to bring data collection in Europe at the level of that in the US and to be able to fully exploit the diversity in Europe to help and understand the effects of social policy on labour supply and retirement and all the related issues discussed above.[2]

SHARE released its first wave of rich individual data on adults ages 50 and older in 2004. Following identical protocols in all participating European countries, this study offers multi-disciplinary data for performing cross-country analyses in Continental

[2] See www.share-project.org

Europe. The measures in the SHARE dataset are also comparable with measures from the U.S. Health and Retirement Study (HRS), a widely used dataset to study issues of older Americans, and the English Longitudinal Study of Ageing (ELSA), a source of data on people aged 50 and over living in England. The baseline 2004 SHARE study included representative data on 28,517 respondents from 11 countries with a balanced representation of the different European regions from Scandinavia (Denmark and Sweden) through Central Europe (Austria, France, Germany, Switzerland, Belgium, The Netherlands) to the Mediterranean (Spain, Italy and Greece). In 2006-2007, a second wave was fielded in these eleven countries, and SHARE extended by adding Poland, the Czech Republic, Ireland, and Israel. The longitudinal aspect of the future SHARE will be particularly valuable for research as more waves become available. Moreover, the longitudinal nature of the data is substantially enriched in the third wave, with a battery of retrospective questions on major life events experienced over the life course. SHARE includes a large set of objective and subjective measures of physical and mental health, psychological conditions (well-being, life satisfaction), socio-economic status (e.g., work activity, job characteristics, income, wealth and consumption, housing, education), and social participation (e.g., family relations, informal care, volunteer activities.

While SHARE provides a good basis, addressing the research challenges identified above would benefit from a number of extensions and improvements:

- Expanding the longitudinal dimension. This is necessary to identify and understand the causal mechanisms that often take many years to become effective, such as the effect of unemployment or other economic shocks on health and well-being. While retrospective measures can help in many respects, not everything can easily be measured retrospectively (e.g., job satisfaction, well-being, cognitive skills, …), so that genuine panel data with complete information on the same individuals over a long period of time remain important.
- Expanding the international dimension. To learn as much as possible from international variation in institutions and policies, more variation in institutions and policies is very useful. For example, the often used distinction between liberal, the conservative, and social democratic welfare systems of Esping-

Andersen (1990) can be used to analyze the consequences of the nature of the welfare system for labour force participation and well-being, but with only a few countries in each regime, it is hard to disentangle this effect from country specific factors (see also the Forward Look paper by Johannes Siegrist and Morten Wahrendorf). Another way of improving the international dimension is to use anchoring vignettes to enhance the comparability of subjective measures of well-being, see, e.g., King et al. (2004) and Kapteyn et al. (2007). Vignettes have been added for a small subsample of the first two waves of SHARE but are not included in the core survey.[3]

- Adding more detailed survey information. The multi-disciplinary nature has its obvious advantages, but also has the drawback that the room for specific questions on topics of interest is limited. For example, nothing is asked about opportunities or preferences for gradual retirement. Adding modules on specific topics would be useful, perhaps only for specific subsamples such as employees in a given age group. One way to do that would be as in the COMPARE project – a project exploiting the SHARE infrastructure to ask, for a limited subsample in a smaller set of countries, the core SHARE questions as well as a module of self-assessments and vignettes on various features of well-being, with the aim of enhancing the international comparability of self-assessed measures of, e.g., health, work disability, income, and job satisfaction. Another possibility would be to interview SHARE respondents on specific topics in years when there is no core survey.

- Merging with administrative data. Many variables are inherently hard to measure in surveys. This particularly applies to economic variables such as income from various sources, assets, or pension entitlements, which are often reported with error or not reported at all. In some countries, survey data have been linked to administrative that originate from, for example, the social security administration or the tax authorities. See, for example, Pischke (1995) for the US and Kapteyn and Ypma (2007) for Sweden. Merging SHARE records with administrative data

[3] See www.compare-project.org.

can help to substantially improve the quality of the economic variables in the SHARE survey and thus also improve the accuracy of model estimates and statistical inference using these variables. In addition, one can think of linking SHARE to other register data such as data on health care utilization that are available in several countries (cf., e.g., Atella et al., 2006).

SHARE is obviously not the only source of data that can be used. For example, it will for some purposes be useful to follow people over time during an earlier part of their labour market career, so that it may be worthwhile to use data from e.g. the European Community Household Panel (ECHP), giving comparable micro data in EU countries for all adult age groups, can be used. Similar extensions as the ones discussed above would in principle also be valuable for the other data sets.

**Data access**

The fact that data exist is not enough – they also need to be used by researchers. In order to achieve this, several conditions need to be satisfied. First, the monetary cost and the conditions for using the data should not hamper their use. SHARE is an excellent example in this respect since the data are free for all academic researchers, and filling out a simple form is sufficient to get access via a secure web-site.

Second, the data must come in a user friendly format with adequate documentation. This is particularly important for panel data which may be impossible to work with for outsiders if not organized and documented in an appropriate way. Making the data user friendly is a major and costly task that should not be underestimated. The prototype example is the RAND version of the Health and Retirement Study in the (the US analogue of SHARE). This is a user friendly version of a large part of the HRS data, with harmonized variables across waves, sophisticated imputations for missing values accounting for follow up bracket questions, constructed variables exploiting preloaded information, etc. etc., making it feasible for researchers to use the HRS for panel data

analysis without having to go through an enormous data preparation effort. A large manpower effort is needed, however, to construct and update such a data base.

Third, workshops where researchers and programmers familiar with the data teach researchers how to use the data may be useful. Such workshops are, for example, organized for the German Socio-economic Panel.

**Exchange of knowledge**

Cooperation between researchers in different countries is useful, particularly if we want to learn about the consequences of differences in institutions such as social security and pension generosity, etc. It would certainly also be useful to create a database with the main features of national institutional arrangements and their reforms, but in addition, personal cooperation and the possibility to consult the national experts will remain necessary.

For many labour supply issues discussed here, insights from various disciplines can be usefully combined (mainly economics and sociology, and to some extent also psychology). Thus cooperation between experts from various disciplines certainly has added value. Such a co-operation has been started because of the development of SHARE and it would be worthwhile to create more such networks.

# 6. Conclusions

Labour supply of older age groups is an important topic, both scientifically and from a policy relevance point of view. Academic research has given many new insights in this during the past 10 years, but one of the main insights that a lot still needs to be learned. There are many research challenges that may fruitfully be addressed in the next five or ten years, particularly if the infrastructure for socio-economic research will be enriched with innovative and higher quality data that are easy to access, and if the exchange of ideas of Europeans in several countries and of various disciplines exchange their knowledge to a larger extent.

# References


Alesina A, Glaeser E, Sacerdote B., (2005), Work and Leisure in the U.S. and Europe: Why So Different? NBER Working Paper No. 11278, NBER, Cambridge (Mass).

Aronsson, T., S.N. Blomquist and H. Sacklén (1999), Identifying interdependent behaviour in an empirical model of labour supply, *Journal of Applied Econometrics,* 14(6), 607-626.

Atella, V., F. Peracchi, D. Depalo and C. Rossetti (2006), Drug compliance and health outcomes: Evidence from a panel of Italian patients, *Health Economics,* 15, 875-892.

Belloni, M., C. Monticone and S. Trucchi (2006), Flexibility in Retirement. A Framework for the Analysis and a Survey of European Countries, Research report commissioned by the European Commission, CeRP, Turin.

Blanchard O. (2004), The Economic Future of Europe, NBER Working Paper No. 10310.

Blau, D. (1994), Labor Force Dynamics of Older Men, *Econometrica*, 62(1), 117-156.

Blau, D. (1997), Social Security and Labour Supply of Older Married Couples, *Labour Economics,* 4, 373-418.

Blau, D. (1998), Labor Force Dynamics of Older Married Couples, *Journal of Labor Economics*, 4, 595-629.

Bonsang, E., S. Adam, C. Bay, S. Germain and S. Perelman (2007), Retirement and cognitive reserve: a stochastic frontier approach applied to survey data, *CREPP working papers* 2007/04, University of Liege.

Burniaux, J.-M., R. Duval, and F. Jaumotte (2004), Coping with ageing: a dynamic approach to quantify the impact of alternative policy options on future labour supply in OECD countries, OECD Economics Department Working Papers, No. 371, OECD, Paris.

Case, A., and A. Deaton (2005), Broken Down by Work and Sex: How our Health Declines, in: David A. Wise (ed.), *Analyses in the Economics of Aging*, The University of Chicago Press, Chicago, pp. 185-212.

Currie, J. and B. Madrian (1999), Health, health insurance and the labor market, in: O. Ashenfelter & D. Card (eds.), *Handbook of Labor Economics, Volume 3A,* North-Holland, Amsterdam, pp. 3309-3416.

Dahl, S.-A, O.A. Nilsen and K. Vaage (2000), Work or retirement? Exit routes for Norwegian Elderly, *Applied Economics,* 32, 1865-1876.

Davis, S. and M. Henrekson M. (2004), Tax Effects on Work Activity, Industry Mix and Shadow Economy Size: Evidence from Rich-Country Comparisons, NBER Working Paper No. 10509, NBER, Cambridge (Mass.).

Disney, R. (2001), Public pension reform in Europe: policies, prospects and evaluation, *The World Economy*, 26(10), 1425-1445.

Disney, R., C. Emmerson and M. Wakefield (2006), Ill health and retirement in Britain: a panel data based analysis, *Journal of Health Economics,* 25, 621-649.

Duval, R (2003), The Retirement Effects of Old-Age Pension and Early Retirement Schemes in OECD Countries, *OECD Economics Department Working Papers*, No. 370. OECD Publishing, Paris.

Estevão, M. and Filipa Sá (2008), The 35 hour workweek in France: straightjacket or welfare improvement? *Economic Policy,* 23(55), 417-463

Esping-Andersen, G. (1990), *The Three Worlds of Welfare State Capitalism,* Cambridge University Press, Cambridge.

Freeman, R. and R. Schettkat, (2001), Marketization of Production and the US-Europe Employment Gap, *Oxford Bulletin of Economics and Statistics*, 63, 647-70.

Galama, T., A. Kapteyn, R. Fonseca, and P-C Michaud (2008), Health, Saving and Retirement, Working Paper, RAND, forthcoming.

Glaeser E., B. Sacerdote and J. Scheinkman. (2003), The Social Multiplier, *Journal of the European Economic Association*, 1(2-3), 345-353.

Grossman, M. (1972), On the Concept of Health Capital and the Demand for Health, *Journal of Political Economy*, 80(2), 223-255.

Gruber, J. and D. Wise (1999), *Social Security and Retirement around the World,* University of Chicago Press, Chicago.

Gruber, J. and D. Wise (2004), *Social Security Programs and Retirement around the World: Micro-Estimation,* University of Chicago Press, Chicago.

Gruber, J. and David A. Wise (2007), *Social Security Programs and Retirement around the World: Fiscal Implications of Reform*, University of Chicago Press, Chicago.

Gruber, J. and D. Wise (2005), Social Security Programs and Retirement Around the World: Fiscal Implications, NBER Working Paper No. 11290, NBER, Cambridge (Mass.).

Gustman, A. and T. Steinmeier (1986), A Structural Retirement Model, *Econometrica*, 54, 555-584.

Gustman, A. and T. Steinmeier (2000), Retirement in Dual-Career Families: A Structural Model, *Journal of Labor Economics*, 18, 503-545.

Gustman, A. and T. Steinmeier (2004), Social Security, Pensions and Retirement Behavior within the Family, *Journal of Applied Econometrics*, 19, 723.

Hartlapp, M. and G. Schmid (2008), Labour Market Policy for "Active Ageing" in Europe: Expanding the Options for Retirement Transitions, *Journal of Social Policy*, 37(3), 409-431.

Hayward, M., W. Grady, M. Hardy and D. Sommers (1989), Occupational influences on retirement, disability and death, *Demography*, 26(3), 393-409.

Heitmueller, A. (2007), The chicken or the egg? Endogeneity in labour market participation of informal carers in England, *Journal of Health Economics,* 26, 536-559.

Henretta, J., A. O'Rand and C. Chan (1993), Joint role investments and synchronization of retirement: a sequential approach to couples' retirement, *Social Forces*, 71(4), 981-1000.

Heyma, A. (2004), A structural dynamic analysis of retirement behaviour in the Netherlands, *Journal of Applied Econometrics,* 19(6), 739-759.

Kalwij, A. and F. Vermeulen (2008), Health and labour force participation of older people in Europe: what do objective health indicators add to the analysis? *Health Economics,* 17, 619-638.

Kantarci, T. and A. van Soest (2008), Gradual retirement: preferences and limitations, *De Economist*, 156(2), 113-144.

Arie Kapteyn and Tatiana Andreyeva (2008), Retirement Patterns in Europe and the U.S., Panel paper No. 6, Netspar, Tilburg University.

Kapteyn, A., A. Kalwij, A. Zaidi (2004), The Myth of Worksharing, *Labour Economics,* 11, 293-313.

Kapteyn, A., J. Smith, A. van Soest (2007), Vignettes and self-reported work disability in the US and the Netherlands, *American Economic Review*, 97(1), 461-473.

Kapteyn, A. and I. Woittiez (1998), Social Interactions and Habit Formation in a Model of Female Labour Supply, *Journal of Public Economics,* 70, 185-205.

Kapteyn, A. and J. Ypma (2007), Measurement Error and Misclassification: A Comparison of Survey and Administrative Data, *Journal of Labor Economics*, 25, 513-551.

Keenay, G., and E. Whitehouse. (2003), Financial Resources and Retirement in Nine OECD Countries: The Role of The Tax System, *OECD Social Employment and Migration Working Papers*, No. 8, OECD, Paris.

Kerkhofs, M., M. Lindeboom and J. Theeuwes (1999), Retirement, financial incentives and health, *Labour Economics*, 6(2), 203-227.

King, G, C. Murray, J. Salomon and A. Tandon (2004), Enhancing the Validity and Cross-cultural Comparability of Measurement in Survey Research, *American Political Science Review,* 98(1), 567-583.

Lumsdaine, R. and O. Mitchell (1999), New developments in the economic analysis of retirement, *Handbook of Labor Economics, Vol. 3C*, O. Ashenfelter and D. Card (eds.), North-Holland, Amsterdam, pp. 3261-3307.

Maestas, N. (2005), Back to Work: Expectations and Realizations of Work after Retirement, RAND Working Paper WR-196.

Nickell, S. (2004), Employment and Taxes, CEP Discussion Paper No 634, Center for Economic Performance, London School of Economics and Political Science.

OECD (2005), Pensions at a Glance: Public Policies Across OECD Countries, 2005 Edition, OECD, Paris.

OECD (2007), Pensions at a Glance: Public Policies Across OECD Countries, 2007 Edition, OECD, Paris.

Pischke, J.-S. (1995), Measurement Error and Earnings Dynamics: Some Estimates from the PSID Validation Study, *Journal of Business and Economic Statistics,* 13, 305-314.

Prescott, E. (2004), Why Do Americans Work So Much More than Europeans? *Federal Reserve Bank of Minneapolis Quarterly Review*, 28(1), 2-13.

Reday-Mulvey, G. (2000), Gradual Retirement in Europe, *Journal of Aging and Social Policy*, 11(2-3), 49-60.

Riphahn, R. (1999), Disability Retirement among German Men in the 1980s, *Industrial and Labor Relations Review,* 52(4), 628-647.

Ruhm, C. (1990), Bridge Jobs and Partial Retirement, *Journal of Labor Economics*, vol. 8, no. 4, pp. 482-501.

Smith, J. (2007), The Impact of Socioeconomic Status on Health over the Life-Course, *Journal of Human Resources,* 42(4), 739–764.

Stock, J. and D. Wise (1990), 'Pensions, the Option Value of Work and Retirement', *Econometrica*, vol. 58, no. 5, pp. 1151-1180.

Van den Berg, G., M. Lindeboom and F. Portrait (2006), Economic Conditions Early in Life and Individual Mortality, *American Economic Review*, 96 (1), 290-302.

Vickerstaff, S., J. Cox and L. Keen (2003), Employers and the management of retirement, *Social Policy and Administration*, 37(3), 271-287.

Wolfe, John R. (1985), A Model of Declining Health and Retirement, *Journal of Political Economy,* 93, 1258-1267.

Table 1 (Table IV from Kalwij and Vermeulen, 2008)

Table IV. Labour force participation men

| Country | Age 50–54 | Age 55–59 | Age 60–64 |
|---|---|---|---|
| Austria | 82.35 | 65.35 | 16.77 |
| Belgium | 79.72 | 51.10 | 18.99 |
| Denmark | 84.05 | 78.26 | 56.49 |
| France | 87.66 | 60.87 | 7.87 |
| Germany | 83.04 | 77.04 | 39.37 |
| Greece | 92.42 | 77.96 | 44.97 |
| Italy | 85.34 | 56.28 | 29.21 |
| The Netherlands | 87.00 | 78.13 | 29.57 |
| Spain | 85.37 | 77.30 | 40.54 |
| Sweden | 93.85 | 82.86 | 67.83 |
| Switzerland | 93.75 | 92.65 | 72.00 |
| Total | 86.33 | 71.18 | 38.20 |

*Note*: Entries are in per cent.

Table 2 (Table V from Kalwij and Vermeulen, 2008)

Table V. Labour force participation women

| Country | Age 50–54 | Age 55–59 | Age 60–64 |
|---|---|---|---|
| Austria | 67.77 | 38.36 | 11.28 |
| Belgium | 59.79 | 30.15 | 7.58 |
| Denmark | 85.92 | 73.62 | 29.46 |
| France | 68.67 | 58.82 | 16.82 |
| Germany | 78.05 | 60.91 | 23.05 |
| Greece | 40.64 | 28.66 | 15.28 |
| Italy | 47.31 | 28.29 | 7.97 |
| The Netherlands | 61.70 | 49.53 | 17.24 |
| Spain | 47.57 | 40.53 | 19.02 |
| Sweden | 84.96 | 79.87 | 62.40 |
| Switzerland | 79.80 | 69.44 | 47.76 |
| Total | 64.35 | 50.00 | 22.65 |

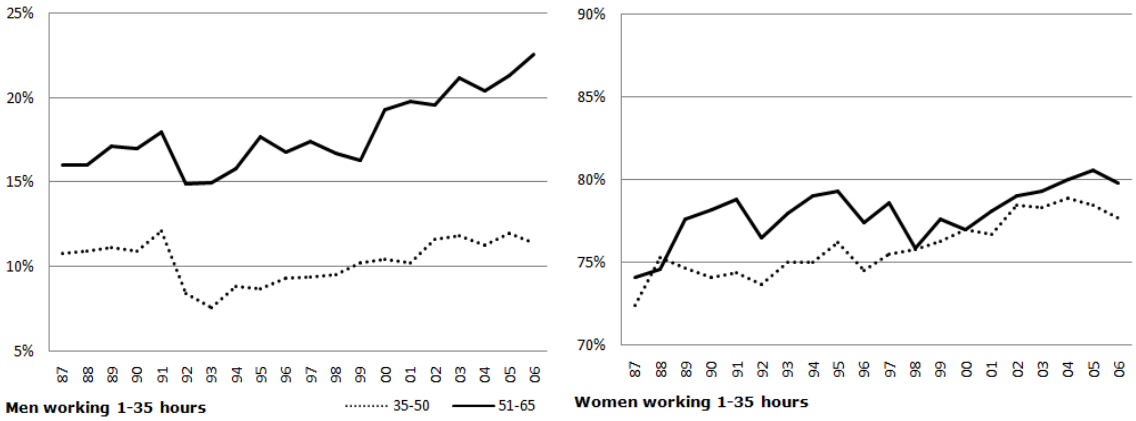
*Note*: Entries are in per cent.

TABLE 3 - PART-TIME WORK OF TOTAL EMPLOYMENT (%)
(source: Kantarci and van Soest, 2008)

| | 1994 | | 1998 | | 2001 | |
|---|---|---|---|---|---|---|
| | 35-50 | 51-65 | 35-50 | 51-65 | 35-50 | 51-65 |
| | Men | | | | | |
| Germany | 2.1 | 7.3 | 2.3 | 8.6 | 2.8 | 2.8 |
| Denmark | 2.5 | 6.8 | 2.4 | 8 | 2.1 | 4.8 |
| Netherlands | 4.6 | 13.4 | 5.3 | 11.6 | 5.7 | 10.4 |
| Belgium | 2.3 | 6.9 | 1.7 | 5.2 | 0.8 | (5.1) |
| France | 5.8 | 9.4 | 1.3 | (3.9) | 1.3 | 3.6 |
| U.K. | 5.1 | 8.9 | 2.5 | 6.4 | 2.5 | 4.8 |
| Ireland | 5.3 | 8.8 | 5.7 | 12 | 5.3 | 11.9 |
| Italy | 5.9 | 10.4 | 2.1 | 5.7 | 1.6 | 4.1 |
| Greece | 6.6 | 9 | 2.1 | 2.6 | 1.2 | 2.8 |
| Spain | 3.7 | 6.5 | 1.9 | 3.4 | 2.2 | 2.9 |
| Portugal | 3 | 9 | 1.3 | 6.8 | 1.1 | 5.3 |
| Austria | *0.7* | *3,5* | 1.8 | (4.2) | 1.9 | 5.8 |
| Finland | *3.3* | *8.5* | 3.2 | 9 | 3.1 | 7.5 |
| Sweden | *2.3* | *6.4* | 1.7 | 6.2 | 1.5 | 4.6 |
| | Women | | | | | |
| Germany | 37.9 | 39.7 | 32.5 | 37.1 | 30 | 33.4 |
| Denmark | 19.4 | 37.3 | 16.9 | 28.6 | 14.7 | 28.6 |
| Netherlands | 63.8 | 68.3 | 63.2 | 64 | 61.6 | 60.4 |
| Belgium | 28.6 | 32.3 | 30.8 | 29.4 | 32.6 | 35.1 |
| France | 23.3 | 27.8 | 17 | 19.7 | 14.3 | 20.3 |
| U.K. | 43.7 | 45.3 | 15.8 | 23.7 | 14 | 26 |
| Ireland | 46.4 | 42.6 | 44.6 | 55.5 | 40.3 | 46.3 |
| Italy | 26.2 | 29.9 | 12.4 | 11.1 | 13.3 | 10.6 |
| Greece | 17 | 21.6 | 9.6 | 18.9 | 7.6 | 17.4 |
| Spain | 21.5 | 23.4 | 16.2 | 24.1 | 19.7 | 22.4 |
| Portugal | 12.5 | 25.6 | 11.7 | 24.8 | 10.8 | 25.2 |
| Austria | *27.6* | *(25.9)* | 29.3 | 31.5 | 30.6 | 27.5 |
| Finland | *8.6* | *12.8* | 9.1 | 15.7 | 8 | 17.3 |
| Sweden | *15.9* | *22* | 16.8 | 20.2 | 13 | 19.4 |

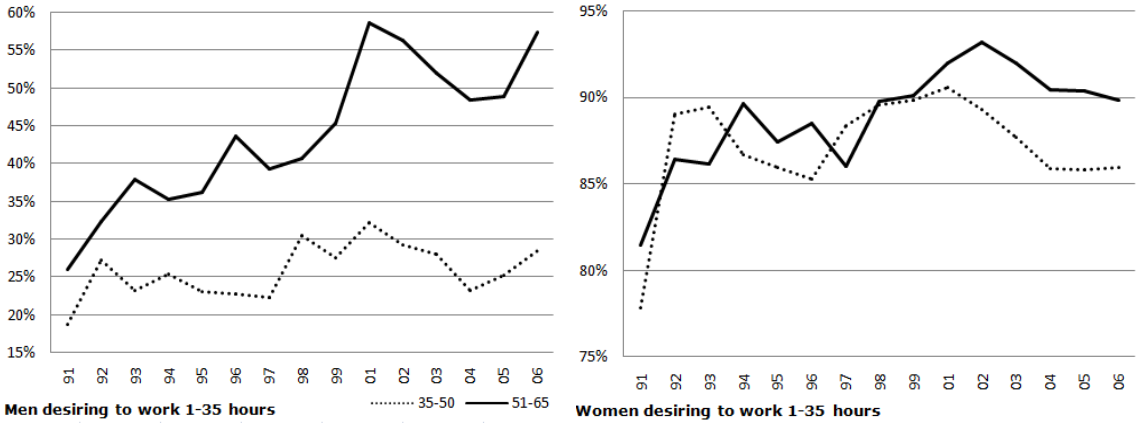
Notes: 1. Based upon self-assessed labour market status. 2. For Germany, Sweden and the U.K, the presented numbers are from national surveys converted into the ECHP format. 3. The numbers in italics refer to the closest survey year that data is available: for Austria it is 1995, for Finland it is 1996, and for Sweden it is 1997. 4. The numbers in parentheses indicate that data are missing for various ages within the age category. 5. The sample is weighted with cross-sectional weights for interviewed persons.

Figure 1 (Figure 2 in Kantarci and van Soest, 2008)




Employees working 1-35 hours. Source: Enquete Beroepsbevolking, Statistics Netherlands; about 60,000 obervations for each cross-section. Observations are weighted with cross sectional weights. The percentages represent the share of those working 1-35 hours in those working any number of hours.

Figure 2 (Figure 3 in Kantarci and van Soest, 2008)




Employees desiring to work 1-35 hours. Source: Enquete Beroepsbevolking, Statistics Netherlands; 5,000 to 9,000 observations for each cross section. Observations are weighted with cross sectional weights. The variable is not available for 2000 and for before 1991. The percentages represent the share of those who desire to work 1- 35 hours in those who desire to work any number of hours.

# Life-course events and later-life employment

By Morten Blekesaune, Mark Bryan and Mark Taylor

Much is already known about how later-life factors and events affect when people exit work. Important determinants of labour market withdrawal include health and disability, individual pension savings and pension entitlements, and job characteristics such as physical strains and job autonomy. Less is known about how earlier life-course events, such as educational achievement, labour market entry and family formation, also affect employment in later life. The purpose of this study was to investigate these relationships, using two sources of longitudinal data: the British Household Panel Survey (BHPS) with supplementary data merged in from the Workplace Employment Relations Survey 2004 (WERS 2004) and the ONS Longitudinal Study (LS).

## Key findings

- There is an association between a man's later life employment and his father's occupational class but not for women. Men brought up in the 'higher' classes have higher employment rates. For men whose fathers were in management or professional jobs, this effect can be explained by these men's higher educational attainments. For the sons of routine non-manual workers or the self-employed, the effect persists after controlling for subsequent life factors including educational achievement, occupation and later life health.
- Better education (O-level or higher) is associated with higher employment rates and fewer transitions out employment in later life.
- The effects of education are particularly strong among women and they are only partially eliminated after controlling for labour market history, family history, job strains and health. For women under 55, having qualifications is associated with about 15 percentage point higher employment probabilities (reducing to around six percentage points for the over 55s).
- Later entry to the labour market is associated with higher employment levels after age 50. A five year delay in entry to employment (up to age 30) is associated with nearly 20 per cent higher employment rates among men and ten per cent higher rates among women. For women, the age at which they enter employment partly determines their occupation and industry, which in turn affect later employment outcomes.
- Both men and women who form their first partnership at a later age (up to about 25 years) are more likely to be in employment after 50 and less likely to leave employment. A five year delay in partnership formation is associated with seven to nine percentage point higher employment probabilities.
- More years of employment before 50 are strongly associated with higher levels of employment in later life (by about 20 percentage points among men and ten points among women for an extra five years of employment). These associations largely remain when controlling for other factors, including current health.
- Men who worked mainly in non-manual occupations are more likely to be in work after 50, while women who were mainly in lesser-skilled occupations are less likely to be employed. Among women, occupational history tends to mediate the effects of previous labour market and family events.
- Being in poor health after 50 is very strongly associated with being out of employment already or with leaving employment. The effects of several earlier life course events are partly mediated by health status. Among men, early entry to the labour market and a lack of continuous employment are related to poor health and hence to lower levels of later-life employment. Among women, rather than employment stability, it is their main occupation which is associated with later health and hence employment outcomes.

## Background

The objectives of this research were to:

- investigate whether a longitudinal life-course approach can help explain the labour market position of people aged 50 and over;
- identify the main life-course events that affect work in later life and how these interact;
- explore whether there are multiple transitions or forms of disadvantage that affect labour market participation and understanding how these interact; and
- investigate if the timing of life-course events affect labour market position after the age of 50.

The focus of the study was whether individuals were working or not at ages 50-70, and their likelihood of making a transition out of employment. A sequential analysis approach was adopted, first investigating the impact of very early life events (to see their 'total' effects on later-life employment), before bringing in subsequent life events to see how they mediate the effects of previous factors.

## Early life events and later life employment

### *Parental background*

Overall, there is little association between a person's parental background and their own later life employment. We find no evidence for either men or women that being the child of a lone parent or an unemployed father leads to lower employment levels in later life. But we do find some influence (for men only) when considering a more detailed categorisation of parental social class. Men brought up in the 'higher' classes – professionals, other non-manual workers and the self-employed – have higher employment rates. Among men whose parents were 'professionals'[1], this can be explained by these men's higher educational attainments. Among the sons of non-manual workers and the self-employed[2], the effect persists after controlling for subsequent life factors including educational achievement, occupation and later life health. Employment rates after 50 for sons of non-manual workers and the self-employed are about ten percentage points higher than for other classes. A possible explanation is that boys in these two classes acquired a work ethic (independently of formal schooling) which favours continuing employment in later life. Of course, our evidence is from past cohorts (the youngest born in the mid 50s) so there is no guarantee that this effect will be reproduced in the future.

[1] The professional group includes managers and administrators, large proprietors and supervisors of non-manual employees, as well as those in strictly defined professional occupations.

[2] Strictly speaking, the self-employed group includes all those in the 'petty bourgeoisie' class (farmers, small employers and self-employed non-professionals). The non-manual group includes sales personnel, routine non-manual employees in administration and commerce.

### *Education*

Unsurprisingly, more education is associated with higher employment rates and fewer transitions out employment. The important distinction is between having no qualifications and having qualifications of O-level or greater (within this group, all qualifications have similar effects). There is some evidence that the education gap shrinks among older people (especially women) as the better qualified withdraw from employment (probably because of better pension entitlements).

The effects of education are particularly strong among women and they are only partially eliminated after controlling for labour market history, family history, job strains and health. For women under 55, having qualifications is associated with about 15 percentage point higher employment probabilities (reducing to around six percentage points for the over 55s). For men, the effect of education is weaker and has an effect mainly via subsequent experience in the labour market – the more educated started work at a later age and have more stable employment. After taking these factors into account, there is little association of education with later-life employment prospects. The effect of education does not seem to be mediated by a man's main occupation or industry, unlike for women.

## Adulthood events and later life employment

### *Labour market entry and family formation*

Later entry to the labour market is associated with higher employment levels after age 50. The effect of labour market entry is strengthened when we hold constant subsequent years of employment – possibly because workers entering the labour market late stay late to accumulate pension entitlements. A five year delay in entry

to employment (up to age 30) is associated with nearly 20 percentage point higher employment rates among men and ten percentage point higher rates among women. For women, the age at which they enter employment partly determines their occupation and industry, which in turn affects later employment outcomes.

Both men and women who form their first partnership at a later age (up to about 25 years) are more likely to be in employment after 50 and less likely to leave employment. A five year delay in partnership formation is associated with seven to nine percentage point higher employment probabilities. However, a substantial part of this effect arises because earlier partnership formation appears to be related to poorer health in later life, and poor health makes employment more difficult. We return to the mediating effects of heath below. For women the partnership effect is also partly mediated by main occupation and industry. The age at which parents had their first child has similar effects to the timing of first partnership formation – starting a family later is associated with higher later-life employment probabilities. However, because partnership formation and having children are often closely spaced events, it is not possible to unambiguously separate their effects.

Perhaps surprisingly, there is little evidence that the timing of family events (after partnership and family formation) has an effect on later withdrawal from the labour market. We found no effects due to having children over an extended period, having had multiple partners, or the timing of partnership dissolution. What seems to count is the timing of initial family formation (as well as getting established in the labour market).

People who never have children are less likely to be in employment after 50. Compared to those with small families, childless men are around six percentage points less likely to work after 50, while employment rates among childless women are 16 percentage points lower (controlling for previous employment history). There is some evidence that those with more than one child are more likely to be in work in later life. The results probably reflect the cost of raising children which delays and reduces pension saving. Parents of very large families are less likely to be in employment after 50 – this seems to be a consequence of their lower employment rates, and the resulting loss of experience and skills, when their children were young (these lower employment rates might in turn stem from lower labour market attachment or more home-centred preferences among these families).

### *Employment history*

More years of employment before 50 are strongly associated with higher levels of employment in later life (by about 20 percentage points among men and ten points among women for an extra five years of employment). These associations largely remain when controlling for other factors, including current health. For men (and much less so for women) years of employment mediate previous educational attainment: being qualified leads to more stable employment and this favours later life employment. There is some evidence that individuals who have changed jobs more often (holding constant years of employment) are more likely to be employed in later life, perhaps reflecting difficulties in carrying pensions across jobs. Periods of unemployment before 50 are associated with lower employment rates among men, with more distant unemployment spells having less effect. We do not find robust evidence of unemployment effects among women.

Men whose main occupation before 50 was in the professional, technical or administrative field work less in later life compared to those in the skilled trades (employment rates are around 15 percentage points lower). Women in the ‘lower’ occupations (especially retail and operative occupations) tend to work less compared to those in administration (by 15-20 percentage points). This gap closes after age 55 (similar to the education relationship) as women in these occupations tend to stay in employment for longer. The occupational pattern of women’s employment mediates the effects of some previous events, notably educational achievement and the timing of partnership formation and labour market entry. In turn, occupation is related to subsequent health and thereby employment outcomes among older women. Compared to men, occupation is more important for women both as an explanatory factor and a mechanism through which other effects are felt.

## Later life events and employment

### *Job strains and health*

Women in jobs with less autonomy tend to work less in later life, and men in less satisfying jobs work less after 50. A one standard deviation increase in job strains is associated three to four percentage point lower employment probabilities, but it is difficult to disentangle these effects

from the direct effects of belonging to particular occupations or industries. However, these job strains seem to act independently of overall health status and so appear to reflect a separate dimension of individual capability.

Being in poor health after 50 is very strongly associated with being out of employment already or with leaving employment. Typically a one standard deviation decline in health is associated with around a ten percentage point lower employment probability and over a one percent higher chance of leaving employment year on year. Health mediates the effects of several earlier life course events. For both men and women, early partnership effects are reduced once we control for health status. Among men, early entry to the labour market and a lack of continuous employment are related to poor health and hence to lower levels of later-life employment. Among women, rather than employment stability, it is their main occupation which is associated with later health status and hence employment outcomes.

### *Other factors*

The effect a spouse's employment history on an individual's later-life employment is minimal. A spouse's **current** employment status is strongly correlated with an individual's employment – but causality probably runs in both directions since it is likely that spouses coordinate their retirement decisions. There is some evidence of a preference for spouses to retire together (though on aggregate, women retire before men).

After controlling for family and employment history and education, we find only a little evidence that having an occupational pension increases transitions out of work. However, our data on pension scheme membership are limited. We find stronger evidence that saving from income increases transitions for men.

## Conclusions and implications

This study has found that both early life-course events and later mediating factors play a role in explaining employment outcomes after age 50, with marked differences in the relative importance of different factors between men and women.

A persistent finding throughout the analysis is that becoming 'established' later in life is associated with a later end to one's career. This applies to the timing of a person's first partnership but especially to their age at labour market entry, and the results generally remain even after controlling for subsequent life events (in particular for men). In addition, the possession of qualifications also favours later life employment. While it is difficult to extrapolate from previous cohorts, our results suggest that raising education levels could favour extended careers, first by delaying labour market entry, and second by reducing the proportion of those with low qualifications (who tend to exit early).

The analysis also highlights the importance of employment stability and occupational factors for later life employment. Indeed several earlier life events affect labour market withdrawal via their effect on a person's experience in the labour market. A person's employment history is in turn linked to later-life health status – a major factor in explaining early withdrawal from employment. This underlines the potential gains from addressing occupational health issues.

Finally, there are complementarities between partners' later life employment behaviour and some evidence of a preference for retiring together. This suggests that if one partner extends their working life, there may be a secondary effect which extends the other partner's employment too.

The study raises several questions which might be addressed in future research. First, to what degree do life-course events affect labour market exit specifically via their effect on pension saving? Second, do the effects of life-course events on labour market exit vary according to destination states, e.g. long-term sickness or retirement? Third, how do the effects of life-course events interact with individuals' preferences regarding labour market withdrawal (as a positive or negative event)? Investigating these issues will require more specific models of labour market withdrawal – for which the present study could be used as a baseline – and well as richer data covering pension savings and entitlements, as retirement preferences.

The full report of these research findings is published by the Department for Work and Pensions (ISBN 978 1 8471 384 8. Research Report 502. June 2008). It is available from Paul Noakes at the address below.

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# Labour Market Incentives for An Ageing Workforce

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## 1. Introduction

Since the year 2000, the EU has set objectives with respect to employment of older workers. In particular, the 2001 Stockholm European Council set a target for 2010, to have at least 50 per cent of the EU population aged 55-64 in employment. The 2002 Barcelona European Council strived to achieve a progressive increase of approximately 5 years in the effective average age at which people stop working in the EU, by 2010.

EU employment guidelines had several actions targeted at older people and the promotion of a lifecycle approach to work. There should be support for active ageing including appropriate working conditions, improved occupational health status and adequate incentives to work and discouragement of early retirement. Modern social protection schemes including healthcare and pensions were to support participation and aim for better retention in employment and longer working lives. Access to training and lifelong learning strategies should be improved.

Since the year 2000, there has been a sharp increase in participation levels. Ireland is now one of the countries to have participation among the age group 55-64 at over 50 per cent. The UK also has a high level of participation. The main increase was among employees rather than self employment, full time and not part time work and in the services sector, non manual knowledge intensive jobs. Inactivity levels are at 46.3 per cent across the EU, below that of other advanced economies. The main reasons for inactivity are retirement (55%), illness (14%) and family (9%). For women, the increase in employment was due to a cohort effect, more women moving into the age category 55-59 and more highly educated. For men, the increase was attributed to policy intervention and reforms to encourage working longer.

The DG for Employment, Social Affairs and Equal Opportunities noted that the Nordic countries had a more integrated approach to active ageing and were more successful in integrating and retaining older workers in employment than other member states. In Norway, employer social contributions were reduced for older workers age 62+, from 12.8% to 8.8%. Similarly in Belgium, employers of people aged 50+ and unemployed 6 months or longer get 50% reduction in social contributions in 1st year, and 25% reduction thereafter.

## 2. Evaluation of Policies

Many countries have policies targeting older workers (Taylor, 2002), including:

- Work-life balance
- removing previous incentives to early retirement;
- encouraging later retirement and flexible retirement;
- legislation to counter age discrimination;
- awareness-raising campaigns among employers;
- guidance and training programmes targeting older workers;
- advice and guidance for employers;

- employment placements;
- support for labour-market intermediaries;
- employment incentive schemes

At the micro-economics level, the impact of these policies on increasing labour market participation for older workers has been addressed in some cases. The objective here is to provide a few examples of this micro-econometric research and this is not an exhaustive analysis.

Age discrimination:
Adams (2004) discussed age discrimination and older workers. Altogether, the results of the paper suggest that age discrimination legislation has succeeded at boosting the employment of older individuals through allowing them to remain in the workforce longer. Evidence to the contrary has been found for people with disabilities by Deleire (2000).

In European countries, there is less evidence available. A thorough literature search is required to see if there has been similar empirical work in any European countries. A preliminary analysis has been carried out in Ireland by Gannon and Munley (2007) – this used a decomposition model to estimate the level of wage discrimination among people with disabilities in the age groups under 45 and over 45. Similar work has been published using UK data (Madden, 2004) and disability discrimination research was carried out by Jones, Latreille and Sloane (2006). Bell and Heitmuller (2005) assessed the impact of Disability Discrimination Act 1996.

Pension Incentives:
In the UK, there is a lot of empirical evidence surrounding pensions and early retirement. More recently, Arkani and Gough (2007) investigated the link between occupational pension schemes and the actual retirement age of men and women. They explored the impact of pension type on employees' expected retirement age and the decision to take early retirement using the English Longitudinal Survey of Ageing (2002-03). Banks, Blundell and Emmerson (2005) examined the possible consequences of the increasing shift from Defined Benefit to Defined Contribution arrangements for private pensions. Whilst much analysis has focused on the possible distribution of investment and job tenure risk, the authors pointed out the additional role for issues relating to adverse selection and to retirement incentives. These issues are illustrated using empirical evidence from the United Kingdom.

In Ireland, there is less empirical economics research on this topic, most likely due to data limitations. The recent SHARE survey asked about public and private benefits including state pensions and occupational pensions.

Retirement decision:
Disney, Emmerson and Wakefield (2006) examine the effect of ill health on retirement decisions in Britain, using the British Household Panel Survey (1991-1998). Using a range of econometric techniques, they show that adverse shocks to individual health stocks predict individual retirement behaviour among workers aged from 50 until state pension age.

In Ireland, the decision to retire is based on a multitude of factors including age, wealth, assets, pensions, social class, health and spousal retirement. Whelan and Whelan (1988) provided summary statistics for some of these reasons, and showed that for people aged 60-65, over one third retired for health reasons, in particular manual workers. Hughes and Stewart (2004) looked at sources of retirement income, but did not explore how expected income impacts on the retirement decision. However, research in Europe and US has explored the impact of many of these factors in more detail, and although social welfare systems and retirement patterns may be different, a review of this literature would provide much valued information to which we can point to gaps in both the national and international literature.

Training Programmes:
Micro evaluation of training programmes is necessary to see what works, similar to evaluation of training programs for younger workers. There appears to be little evidence of empirical analyses of training programmes for older workers.

## 3. Some results for Ireland

In Ireland, there is less micro-economic empirical research on labour market policies and retirement decisions, most likely because individual level data had not been collected to the same extent as in the US, the UK and in other countries. Studies on the determinants of retirement decisions and influence of economic incentives have not been carried out at the micro level. While Fahey and Russell (2002) looked at individuals' preferences for retirement, the level of data is not sufficient to warrant good causal estimates of the effects of health and pensions on retirement. The Living in Ireland data includes relevant data on health, pensions, income and work but the sample of workers aged 50 plus and aged 55-64 is quite small and transitions into retirement are not available, compared to the BHPS or GSEOP where the sample sizes are much larger.

The first paper to use the Living in Ireland data for workers aged 50 and over was by Gannon and Roberts (2007) and this analysed the decision to work part time, full time or retire. Different results were obtained for Ireland and UK. The impact of health on part-time work was negative in Ireland, but the authors found no significant effect in the UK. The paper discussed potential reasons for these impacts and current policies on part-time work. The authors now propose to improve the precision of these results by controlling for endogeneity of health and exploring other options such as the number of hours worked per week. It was not possible to look at transitions into retirement with the small sample sizes.

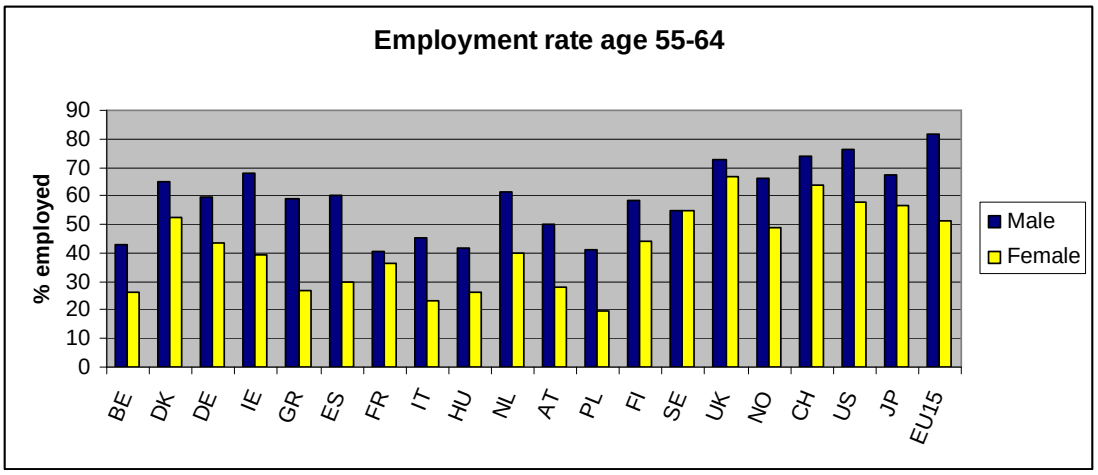
The SHARE data is now available for Ireland and the first report on this data indicates that a large proportion of respondents were working at age 50-59, but this is reduced significantly by age 60-69 (Harmon *et al*., 2008). The proportion of women who are retired rises from less than 10 per cent for those aged 50-59 to over 50 per cent for those aged over 70. The next stage is to use this data to estimate the causal impact of health and pensions on retirement. The data sample includes over 1,000 observations and if data on wave 2 is collected and follows the same individuals over time, the transition into retirement may then be explored further.

Other research on the influence of financial incentives on reported disability status uses the sample of workers in all age groups. But a sub-group analysis of retirees indicates that when measurement error is corrected for, less individuals are likely to report a disability if they reported as if they were employed (Gannon, 2008).

## 4. What research gaps remain?

Interestingly some countries have reached the EU target of 50 per cent in employment. Figure 1 shows the exact rates for a selection of European and other countries. With comparative research we can establish how some countries achieved this target and why some other countries are well below the proposed rates.

**Figure 1**




Source: Eurostat

In Ireland, research is required on micro-econometric analysis of labour market decisions and incentives to work for older people. The ICSG are currently undertaking a program of research whereby they are doing a complete literature review of empirical studies in other European countries on the following topics:

- Determinants of hiring older workers
- Decision to retire and influence of health and pensions
- Effects on productivity of older age
- Age discrimination and disability
- Evaluation of training programs
- Effects of increasing the retirement age
- Self employment and entrepreneurship
- Part time working

This will allow us determine what research is required in Ireland and how we can contribute towards the international debate and economics literature.

## 5. Conclusion

Population ageing will lead to a marked change in the age structure of the population and workforce. Increasing labour force participation of older people will be essential, by addressing reasons for their inactivity. A comprehensive active ageing strategy must focus on entire working lifespan for all age groups and not just on older workers.

A detailed review of the economics literature will highlight the gaps in research necessary to support employment policies and the supply of older workers. This will be of particular relevance to countries that have, to date, less research on these topics.

**References**


Adams, S. (2004) "Age discrimination legislation and the employment of older workers", *Labour Economics*, pp. 219-241.

Arkani, S. and O. Gough (2007) "The impact of occupational pensions on retirement age", *Journal of Social Policy*, 36(2):297-318.

Banks, J., Blundell, R. and C. Emmerson (2005) "The Balance Between Defined Benefit, Defined Contribution, and State Provision", *Journal of European Economic Association*, Vol. 3(203):466-476.

Bell, D. and A. Heitmueller, (2005), "The disability discrimination Act in the UK: helping or hindering employment amongst the disabled?", IZA Discussion Paper No. 1476**.**

Deleire, T. (2000) "The wage and employment effects of the Americans with Disabilities Act", *Journal of Human Resources*, 35(14): 693-715.

Disney, R., Emmerson, C. and M.Wakefield, (2006), "Ill health and retirement in Britain: A panel data-based analysis," *Journal of Health Economics*, Vol. 25(4): 621-649.

Fahey, T. and H. Russell (2002) *Older People's Preferences for Employment and Retirement in Ireland*. Dublin: National Council for Ageing and Older People.

Gannon, B. (2008) "The influence of financial incentives on reported disability status", *Health Economics*, online.

Gannon, B. and J. Roberts (2007) "Part-time work and Health among Older Workers in Ireland and Britain", WP-ICSG-2007-01.

Gannon, B. and M. Munley (2007) "Age and Disability in Ireland: Is there wage discrimination?" WP-ICSG-2007-02.

Harmon, C., Delaney, L., Kennedy, J., Kelleher, C., Gannon, B. and E. O'Shea (2008). Survey of Health Ageing and Retirement in Europe, First Results for Ireland.

Hughes, G. and J. Stewart (2004) Reforming Pensions in Europe: Evolution of Pension Financing and Sources of Retirement Income, Edward Elgar.

Jones, Latreille and Sloane (2006) "Disability, gender and the British labour market", Oxford Economic Papers, Vol. 58, 407-449.

Madden, D. (2004), "Labour market discrimination on the basis of health: an application to UK data", *Applied Economics*, 36:421-442.

Taylor, P. (2002) “New policies for older workers’. Joseph Rowntree Foundation, The Policy Press.

Whelan, C. and B. Whelan, (1988). "The Transition to Retirement," Research Series, Economic and Social Research Institute (ESRI), No. GRS138.

# Human Capital, Retirement and Pension Saving

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Preliminary, comments welcome

## 1 Introduction and policy questions

Most Western governments will be confronted with the consequences of demographic ageing in the upcoming decennia. Tax bases will shrink due to the retirement of older generations of workers and outlays on state pensions and health care will rise substantially. At the same time, many European countries are confronted with a vicious circle of low investments in training on-the-job (OJT) of older workers and strong incentives to retire early. Individuals do not invest in skills because they expect to retire early and individuals retire early because they have not invested in skills. Pension systems with intergenerational risk-sharing face difficulties as well, since it will become more difficult and costly to smooth pension risks over different generations by means of contribution adjustments if the number of pensioners rises substantially relative to the number of workers.

Governments therefore aim to promote labor market participation of older workers and to improve their employability so as to broaden tax bases. All European countries have also subscribed to the Lisbon agenda. One of its targets is that the European Union average level of participation in Lifelong Learning should be at least 12.5% of the adult working age population (25-64 age group) by 2010. Most countries have therefore started to implement 'life-long learning' policies to promote investments in OJT so as to raise labor productivity and to improve employability of especially older workers.

For the same reasons, (early) retirement schemes and labor markets are reformed in order to stimulate later retirement. In the past, implicit taxes on continued work have often been so high that individuals were 'stealing their own wallet' if they did not retire early. In addition, many governments stimulate private pension saving, for example through tax-favored saving schemes, so as to reduce the dependency of pensioners on state pensions and collective occupational pension-schemes.

*This paper covers a very broad research area, which crosses numerous sub-disciplines. I want to apologize at the outset for the fact that I have not done justice to the scientific work of many scholars that I have not mentioned due to my limited in-depth knowledge of the various fields covered in the paper and the large time-pressure under which this paper was written. All errors and omissions are mine. I thank the Dutch Organization for Sciences for financial support (Vidi Grant No. 452-07-013, 'Skill Formation in Distorted Labor Markets').

Measures to reform retirement and pension schemes will indirectly also affect the incentives to invest in human capital over the lifecycle. By extending the time-horizon over which investments in skill materialize, a higher retirement age will promote investments in OJT. Later retirement and OJT-investment are therefore complementary. Generous support for pension savings may indirectly discourage investment in OJT. Human and financial capital are substitutes over the lifecycle. Stimulating financial saving therefore implies that saving in human form is discouraged.

Furthermore, labor market institutions and welfare state arrangements are often blamed for distorting the incentives to maintain skills over the lifecycle and to promote early retirement. Labor markets institutions, such as employment protection, wage setting of unions, incentive schemes in wage-setting and minimum wages, could rotate the wage profile over the lifecycle and may result in wage compression. This may be the consequence of various welfare state arrangements that affect wage-setting, such as benefits for sickness, disability, and unemployment, pensions, early retirement schemes. Typically, the value of outside options for workers increases as they become older. Both wage compression and rotation of wage profiles can harm the incentives to invest in skills. In particular, by reducing the wage differences between skilled and unskilled workers, the incentives to become skilled diminish. Further, by rotating the wage-profile over the lifecycle, younger workers will invest too much and older workers too little in human capital.

A number of policy-relevant implications appear from this discussion:

- Promoting life-long learning or later retirement will not be effective if strong disincentives caused by labor market institutions, early retirement schemes and incentives for pension savings remain in place.
- Promoting private savings for old-age may inadvertently create implicit taxes on skill formation and indirectly stimulate early retirement, thereby worsening the ageing problems.

Any policy reform should take into account the dynamic interactions of OJT-investment, retirement and pension saving. Moreover, labor market institutions and welfare state arrangements are crucial to understand economic incentives in labor markets. Unfortunately, little is known about lifecycle interactions between learning, retirement and saving. Generally, training, (pension) saving and wage determination are separately analyzed, and no generally accepted theories are available to simultaneously address these issues.

This paper therefore first starts with developing a Ben-Porath (1967) human capital model of OJT which is firmly grounded in neoclassical human capital theory (see for example Mincer, 1958, 1962, 1974; Schultz, 1963; and Becker, 1964). The model is extended with a discrete, endogenous retirement decision as in Jacobs (2008). This model allows us to theoretically analyze the interactions between investment in OJT, retirement and saving. Simulations of the model with various tax and retirement policies already provide important insights into the main mechanisms that are at work. Although this is of separate scientific interest, it is only done to provide a parsimonious framework that allows us to consistently organize our thoughts.

After having developed the theoretical structure, we will discuss in more detail the underlying assumptions, the empirical content of the model, and various competing theories. Subsequently,

we will elaborate on various theoretical, empirical and methodological issues when bringing the theory to the data. We will also discuss the remaining gaps in knowledge and provide some directions for future research.

## 2 A stylized model of training, retirement and saving

We follow Heckman and Jacobs (2006) and Jacobs (2008) by adding an endogenous retirement decision to the otherwise standard Ben-Porath (1967) model of OJT-investments, see also Heckman (1976) and Weiss (1986). This is the canonical model to think about OJT. Although savings are made to ensure consumption smoothing over the lifecycle, most savings will be made for the retirement period in which individuals have no labor earnings. We abstract here from endogenous (initial) education and labor supply decisions on the intensive margin, i.e. hours of work. A partial equilibrium setup is chosen in which the paths of rental rates for human capital and interest rates are exogenously given. This would be the case in small, open economies with perfect capital mobility and perfect substitution between labor types in labor demand. Capital and labor markets are perfectly competitive and frictionless.

We assume that a representative individual is born at time $t = 0$ and has a life-span $T$ which is exogenously given. At $t = 0$ the individual enters the labor market. The individual retires at date $R < T$. The life-time time constraint states that total time in the labor market $R$ and in retirement $T - R$ should equal the life-span $T$ of the individual: $T = R + (T - R)$.

While being in the labor market, the individual may devote part of his time to training on-the-job. The time constraint during the working life implies that the fraction of time working $1 - I(t)$, plus the fraction of time invested in training $I(t)$ should be equal to the total time endowment, which is normalized to one.

At each date, the individual derive instantaneous utility $U(C(t))$ from consumption $C(t)$. Individuals derive utility $X(T - R)$ from the years they are retired $T - R$. Retirement is a discrete decision to exit the labor market completely. We therefore assume that the retirement decision is not a zero hours worked 'corner-solution' (for more discussion, see Jacobs, 2008).

Life-time utility of the individual is a time-separable function of instantaneous consumption felicities and retirement utility

$$\int_0^T U(C(t)) \exp(-\rho t) dt + X(T - R), \tag{1}$$

with $U'(C(t)) > 0$, $U''(C(t)) < 0$, $X'(T - R) > 0$ and $X''(T - R) < 0$. $\rho$ is the subjective rate of time preference.

The individual starts his life with $A(0) \equiv A_0$ in financial assets which are normalized to zero for convenience ($A_0 \equiv 0$). Borrowing and lending on a perfect capital market is possible at constant real interest rate $r$. Upon entering the labor market, the individual starts earning gross labor income $W(1 - I(t))H(t)$. $W$ is the rental rate of human capital, which is time-invariant. $H(t)$ is the stock of human capital which is gathered through training on-the-job in a manner that is made precise below. The flow budget constraints until retirement ($0 < t \leq R$) state that the increase in financial assets should equal total interest income, net labor income minus

consumption

$$\dot{A}(t) = (1-\tau_A)rA(t) + (1-\tau_L)W(1-I(t))H(t) - C(t), \quad 0 < t \leq R, \tag{2}$$

where $\tau_L$ is the labor income tax rate and $\tau_A$ is the interest tax (or subsidy when negative).

During retirement ($R < t \leq T$) the individual runs down his accumulated assets for consumption purposes:

$$\dot{A}(t) = (1-\tau_A)rA(t) + (1-\tau_P)P - C(t), \quad R < t \leq T, \tag{3}$$

where $P$ is the time-invariant retirement benefit, and $\tau_P$ denotes the rate at which retirement benefits are taxed. One should interpret the pension benefit $P$ as that part of pension benefits that is actuarially completely non-neutral, since individuals only receive retirement benefits conditional upon full retirement. Any actuarially fair pension savings are covered by the voluntary saving decision. The individual has no bequest motive and ends his life with zero wealth: $A(T) \equiv 0$.

The individual can increase his human capital by allocating time $I(t)$ to learning activities, while foregoing labor earnings. Without loss of generality, it's assumed that on-the-job training does not require direct costs (for that case, see Ben-Porath, 1967; Heckman, 1976). The individual starts out with $H(0) \equiv H_0 > 0$ units of on-the-job human capital when he enters the labor market. On-the-job human capital accumulates according to a Ben-Porath (1967) type of production function

$$\dot{H}(t) = BF(I(t)H(t)) - \delta H(t), \quad 0 < t \leq R, \tag{4}$$

where $B > 0$, $F'(I(t)H(t)) > 0$, $F''(I(t)H(t)) < 0$. $B$ is a general productivity parameter. There is dynamic complementarity in human capital formation on-the-job because the marginal product of training investments increases with the level of human capital $H(t)$. Hence, large (small) early investments in human capital boost (reduce) later investments in human capital. $\delta$ denotes the rate of depreciation of human capital.

Integration of the asset accumulation constrains and imposing the initial and terminal conditions on financial wealth ($A(0) = A(T) = 0$) gives the life-time budget constraint of the individual

$$\int_0^T C(t)\exp(-r^*t)dt = \int_0^R W^*(1-I(t))H(t)\exp(-r^*t)dt + \int_R^T P^*\exp(-r^*t)dt, \tag{5}$$

where $r^* \equiv (1-\tau_A)r$, $W^* \equiv (1-\tau_L)W$, and $P^* \equiv (1-\tau_P)P$ denote the after-tax values of the interest rate, rental rates and pensions.

The individual maximizes life-time utility by choosing consumption (saving), on-the-job training, and retirement subject to the household budget constraint, the time constraints and the accumulation equation for on-the-job human capital. The Hamiltonian for this optimal control problem can be written as follows

$$\max_{\{C(t),R,I(t),H(t)\}} \mathcal{H} \equiv \int_0^T U(C(t))\exp(-\rho t)dt + X(T-R) + \mu(t)\left[BF(I(t),H(t)) - \delta H(t)\right] \tag{6}$$

$$+\lambda_0 \left[ \int_0^R W^*(1-I(t))H(t)\exp(-r^*t)dt + \int_R^T P^*\exp(-r^*t)dt - \int_0^T C(t)\exp(-r^*t)dt \right],$$

where $\lambda_0$ is the marginal utility of life-time income, $\mu(t)$ is the co-state variable at time $t$ associated with the on-the-job human capital accumulation equation, and $H_0$ is given. In the remainder we assume that all solutions to the maximization problem are interior. Therefore, we ignore the non-negativity constraints on all decision variables. Most of these constraints are trivial, except for one: the non-negativity constraint on working time ($I(t) \leq 1$). This implies that individuals always work some positive amount of time (if not retired) and are never choosing a corner where they invest full-time in OJT. Like Heckman (1976) we feel that the analysis of 'corners', as pursued for example in Ben-Porath (1967) and Weiss (1986) distracts from the main mechanisms at work.

The first-order conditions for a maximum are given by[1]

$$\frac{\partial \mathcal{H}}{\partial C(t)} = U'(C(t))\exp(-\rho t) - \lambda(t) = 0, \quad 0 < t \leq T, \tag{7}$$

$$\frac{\partial \mathcal{H}}{\partial R} = -X'(X-R) + \lambda_R\left((1-\tau_L)W(1-I_R)H_R - (1-\tau_P)P\right) = 0, \tag{8}$$

$$\frac{\partial \mathcal{H}}{\partial I(t)} = \mu(t)BF'(I(t)H(t))H(t) - \lambda(t)(1-\tau_L)WH(t) = 0, \quad 0 < t \leq R, \tag{9}$$

$$\frac{\partial \mathcal{H}}{\partial H(t)} = \mu(t)\left[BF'(I(t)H(t))I(t) - \delta\right] + \lambda(t)(1-\tau_L)W(1-I(t)) = -\dot{\mu}(t), \quad 0 < t \leq R, \tag{10}$$

where $\lambda(t) \equiv \lambda_0 \exp(-r^*t)$ denotes marginal utility of income at date $t$. In addition we have to impose a transversality condition on the co-state variable stating that the marginal value of human capital is zero at the date of retirement

$$\mu_R H_R \exp(-(1-\tau_A)rR) = 0. \tag{11}$$

Using standard routines we obtain the Euler equation for consumption

$$\frac{\dot{C}(t)}{C(t)} = \theta(t)\left((1-\tau_A)r - \rho\right), \quad 0 \leq t \leq T, \tag{12}$$

where $\theta(t) \equiv \left(-\frac{U''(C(t))C(t)}{U'(C(t))}\right)^{-1}$ is the intertemporal elasticity of substitution in consumption. If the rate of time preference is lower than the real after-tax return on financial saving, consumption features an upward sloping profile over the lifecycle. A larger intertemporal elasticity of substitution results in a stronger upward sloping consumption profile and a stronger sensitivity of savings with respect to net after-tax returns.

[1] We assume that first-order conditions are necessary *and* sufficient. The latter condition is not necessarily fulfilled due to the feedback between retirement and human capital accumulation. Only sufficiently strong decreasing returns in human capital formation and sufficiently concave retirement sub-utility ensure an interior solution. We assume that these conditions are met.

Optimal retirement is given by (note that $I_R = 0$ at the end of the working life, see below)

$$\frac{X'(T-R)}{\lambda_R} = (1-\tau_R)\,(1-\tau_L)WH_R, \tag{13}$$

and $\tau_R \equiv \frac{(1-\tau_P)P}{(1-\tau_L)WH_R}$ denotes the net replacement rate of retirement income in terms of final earnings. $\tau_R$ is the implicit tax rate on continued work due to non-actuarially fair pension benefits. The marginal willingness to pay for an additional year in retirement should be equal to the marginal costs of an extra year in retirement. The marginal benefit is the marginal rate of substitution between retirement utility and consumption at the date of retirement. The marginal costs are given by the value of the net forgone labor earnings in the last year on the labor market. Note that the implicit tax on retirement $\tau_R$ is added to the explicit labor tax $\tau_L$ on retirement. Both result in earlier retirement. However, the direct tax is often overlooked in retirement studies, which focus mainly on the implicit tax. $\lambda_R$ captures wealth effects in the retirement decision. Richer individuals have a lower marginal utility of income and retire earlier – ceteris paribus. Note that a higher tax on (pension) saving $\tau_A$ delays retirement, since the effective discount rate at which retirement utility is discounted increases, since $\lambda_R = \lambda_0 \exp(-(1-\tau_A)rR)$. A lower interest rate effectively enlarges the time-horizon over which decisions are made. The individual has stronger incentives to retire later if he has more human capital $H_R$, since more human capital raises forgone labor earnings while being in retirement. Thus, better-skilled workers retire later when the income effect of higher skills are outweighed by the substitution effects of higher skills. Similarly, if individuals do not train and end their career with low levels of human capital, the incentive to retire will be stronger.

Investment in on-the-job training is governed by

$$(1-\tau_L)W = m(t)BF'(I(t)H(t)), \quad m(t) \equiv \mu(t)/\lambda(t), \quad 0 \le t \le R. \tag{14}$$

This equation states that the marginal costs of an hour devoted to on-the-job human capital investment ($(1-\tau_L)W$) should be equal to the discounted value of marginal benefits in terms of higher future wages $m(t)BF'(I(t)H(t))$. $m(t)$ discounts the stream of future wage increases $F'(I(t)H(t))$ back to time $t$. $m(t)$ is therefore the marginal value of one unit of human capital at time $t$. Investment in on-the-job human capital increases if the marginal value of one unit of human capital is large (high $m(t)$) and if the opportunity costs, in terms of forgone labor earnings, are low (low $(1-\tau_L)W$). Moreover, investments in human capital tend to increase if the individual has a larger stock of human capital (large $H(t)$). This is due to the dynamic complementarities in human capital accumulation. Finally, investment in OJT increases if the individual has a higher exogenous productivity of learning $B$. $B$ captures, for example, the level of initial education before entering the labor market. Thus, better educated individuals would invest more in OJT during the lifecycle.

From the first-order condition for $H(t)$ we find a first-order differential equation for the marginal value of a unit of human capital.

$$\dot{m}(t) - ((1-\tau_A)r + \delta)m(t) = -(1-\tau_L)W, \quad 0 \le t \le R. \tag{15}$$

This equation can be solved analytically (after using the transversality condition $m_R = 0$):

$$m(t) = \frac{(1-\tau_L)W}{((1-\tau_A)r+\delta)}\left(1-\exp[((1-\tau_A)r+\delta)(t-R)]\right), \quad 0 < t \leq R. \tag{16}$$

The marginal value of a unit of human capital at time $t$ is increasing with the effective net wage rate at date $t$, $(1-\tau_L)W$, decreasing with the depreciation adjusted real interest rate $((1-\tau_A)r+\delta)$, and decreasing with the remaining time-span over which the returns in human capital are harvested, i.e. a smaller $[1-\exp[((1-\tau_A)r+\delta)(t-R)]]$. Note that the last term is an annuity term capturing the finite time-horizon of the investment in human capital. A higher interest rate (or depreciation rate) effectively shortens the time-horizon of individuals. The marginal value of human capital $m(t)$ is independent from initial wealth, due to the assumption of perfect capital markets. Hence, all individuals with different wealth endowments would make the same human capital investments (ceteris paribus).

The marginal value of human capital declines continuously over the lifecycle:

$$\dot{m}(t) = -(1-\tau_L)W\exp[((1-\tau_A)r+\delta)(t-R)] < 0, \quad 0 < t \leq R. \tag{17}$$

The reason is that the time over which the returns to the investments can be reaped falls as individuals age. Hence, investment in human capital $I(t)Ht)$ falls continuously over time, until it becomes zero at the date of retirement $t = R$. Intuitively, positive investments then have no remaining value, since the returns on OJT are zero if individuals are retired.

Substitution of $m(t)$ into the first-order condition for $I(t)$ gives an arbitrage condition saying that the return on the investment in human capital must be equal to the net-return on financial saving plus the rate of depreciation:

$$BF'(I(t)H(t))\left(1-\exp[((1-\tau_A)r+\delta)(t-R)]\right) = (1-\tau_A)r+\delta, \quad 0 \leq t \leq R. \tag{18}$$

Note that the labor tax does $\tau_L$ not affect the net return to human capital, since all opportunity costs and benefits from investments in human capital receive a completely symmetric tax treatment (Heckman, 1976). Note also that a higher tax on financial saving makes human capital investment more attractive by lowering the effective rate at which future wage increases are discounted and by increasing the effective time-horizon of the individual.

From the production function for human capital $\dot{H}(t)+\delta H(t) = BF(I(t)H(t))$, we can trace out $H(t)$ until $H(R)$ from any $H(0) = H_0 > 0$. Also, the last equation is a first-order linear differential equation, which has the solution

$$H(t) = H_0\exp(-\delta t) + \int_0^t BF(I_v H_v)\exp(-\delta(t-v))\,dv, \quad 0 < t \leq R. \tag{19}$$

The stock of human capital at time $t$ equals the depreciation-corrected initial stock of human capital, plus the depreciation-corrected sum of investments made during the lifecycle until $t$.

## 3 Simulations

To gain more insight in the comparative dynamics of the model, we simulate it for a reasonable set of parameters. To that end, we need to put some structure on the utility function and the production function for human capital. We assume that utility is captured by relatively standard CES sub-utility functions

$$\int_0^T \frac{C(t)^{1-1/\theta}}{1-1/\theta}\exp(-\rho t)dt + \gamma\frac{(T-R)^{1-1/\beta}}{1-1/\beta}, \quad \theta,\gamma,\beta > 0, \tag{20}$$

where $\theta$, $\gamma$, and $\beta$ denote the inter-temporal elasticity of substitution in consumption, a preference parameter for retirement and the retirement elasticity. The human capital production function is Cobb-Douglas

$$F(I(t)H(t)) = (I(t)H(t))^{\alpha}, \quad \alpha > 0, \tag{21}$$

where $\alpha$ is the elasticity of the human capital production function. The simulations use a discrete-time version of the model, which is derived in the appendix.

The time-span is set at 60 years, hence $T = 60$. We assume that individuals start working at age 20 so that individuals die at age 80. Consequently, we ignore the initial education phase. This might be captured by a higher productivity $B$ of investments in human capital. A pure rate of time preference of $\rho = 0.025$ is chosen, which is fairly standard. The same is true for the real interest rate, which is set at $r = 0.05$. After an extensive review of the scarce empirical literature, Trostel (1993) sets the elasticity of the human capital production function at $\alpha = 0.6$. We employ the same value in our simulations. Furthermore, we set the depreciation rate of human capital at a relatively low value of $\delta = 0.02$. Indeed, most earnings profiles do not tend to level off much at the end of the lifecycle, hence depreciation of human capital appears to be modest (Heckman et al., 1998).

In the appendix we demonstrate that the uncompensated elasticity of retirement – at constant levels of human capital – is given by $\frac{(T-R)}{R}\beta\left(1-\frac{1}{\theta}\right)$. Consequently, both the intertemporal elasticity of substitution $\theta$ and the retirement elasticity $\beta$ jointly pin down the retirement elasticity. The estimates in Gruber and Wise (1999, 2002), OECD (2004), and Duval (2004) imply that the uncompensated elasticity of labor force participation of older workers with respect to the implicit tax on retirement (thus including wealth and income effects) is approximately one third. We employ a more conservative value of 0.2. Moreover, we need to assume an intertemporal elasticity of substitution in consumption $\theta$ larger than unity so as to find a positive uncompensated retirement elasticity. We have set it at $\theta = 1.25$ in our simulations. A value of $\theta = 1$ is often used in real business-cycle models, see e.g. Lucas (1990). Although the empirical estimates vary considerably, a value of $\theta = 0.5$ is suggested by most empirical micro-economic research, see for example Attanasio and Weber (1995). However, values of $\theta < 1$ imply backward bending 'retirement curves', which are clearly counter factual. By setting $\theta = 1.25$ we obtain realistic retirement behavior and avoid too large wealth/income effects in retirement. Finally, a value of $\beta = 2$ pegs the uncompensated retirement elasticity at 0.2 at a calibrated retirement age of $R = 40$ (age 60) and a life-span of $T = 60$.

The baseline set of policy variables is $\tau_L = 0.5$, $\tau_A = 0.30$, and $\tau_R = 0.3$. These values match unweighted averages for a sample of 16 continental European and Anglo-Saxon countries (see also Jacobs, 2008). Total marginal tax wedges on labor income (including employer contributions and local taxes) are 51% for a single household without dependents which earns the average production wage (OECD, 2007). The effective marginal tax rate on capital income is harder to obtain given the large differences in tax treatments of various sources of capital income in different countries (see for example Carey and Rabesona, 2004). For this moment we have set it at 30%. Gruber and Wise (1999), OECD (2004), and Duval (2004) show that the implicit tax on retirement amounts to around 30% for an older worker aged between 55–65, although there are substantial cross-country differences.[2]

The remaining parameters ($W, B$ and $\gamma$) are calibrated such that the individual retires at age 60 ($R = 40$), he invests 71% of his time at the start of his career in human capital (i.e., $I(t) = 0.71$ at $t = 0$, or age 20) and the individual's gross labor earnings per year are 30.6 (thousand euro) on average during working-life. The calibrated values for the remaining parameters are: $W = 25.4$, $B = 0.09$, and $\gamma = 2.4$. Tax revenues are absorbed by the government to finance spending on public goods and are not rebated.[3]

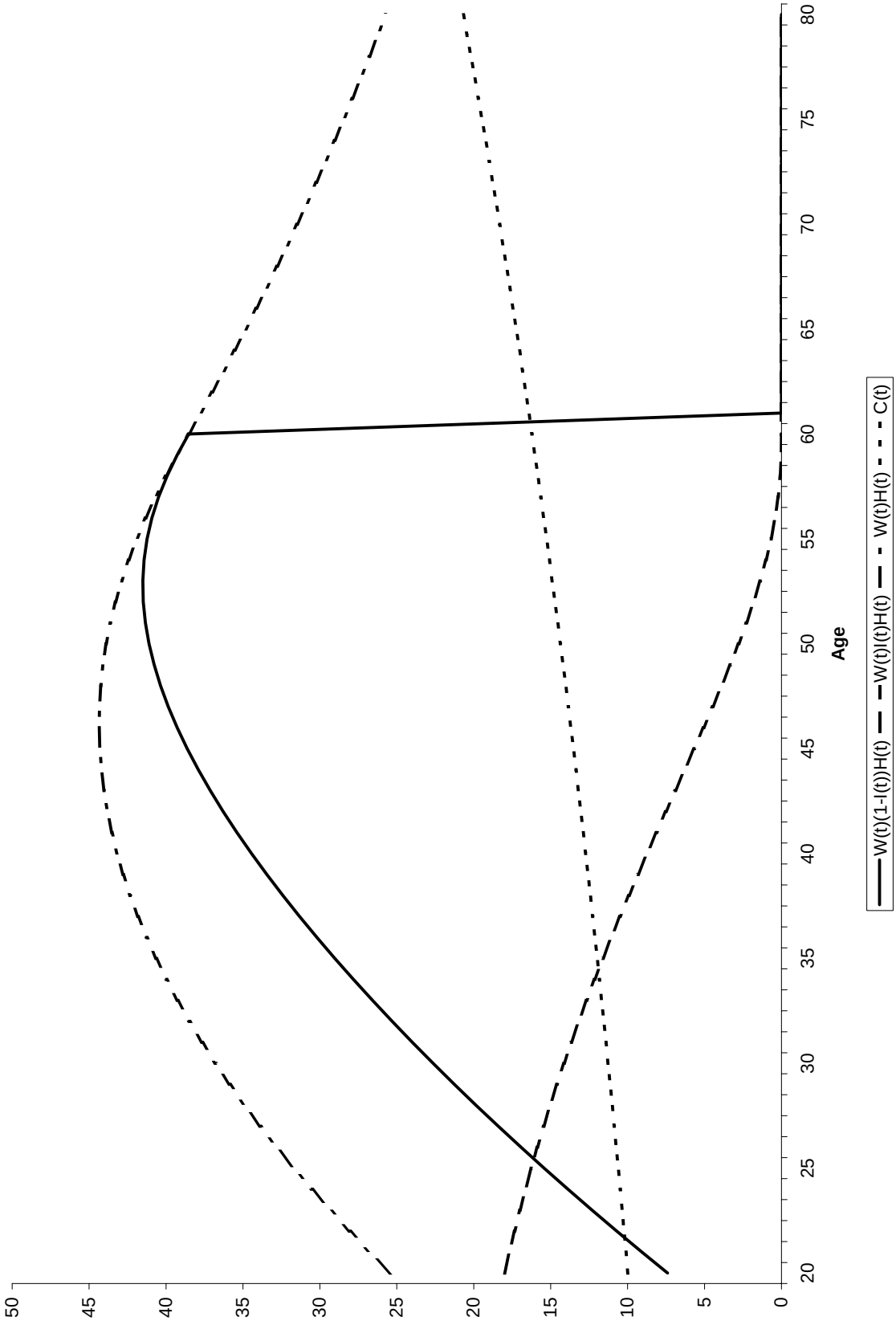
The baseline time-paths of consumption, the value of total investment in human capital ($WI(t)H(t)$), total labor earnings ($W(1 - I(t))H(t)$) and total human capital ($WH(t)$, scaled with rental rates) are plotted in Figure 1. Investment in human capital is high at the beginning of the working career, and declines monotonically until the retirement age is reached. The reason is that the payback time of investments continuously decreases, hence returns on investments fall over time. Indeed, labor earnings drop to zero at the retirement age of 60. The lifecycle profile of labor earnings steadily increases until it peaks at age 53 and then decreases slightly afterwards. This reflects both the investment in OJT before the peak and the depreciation of human capital after the peak. There would be no decline in labor earnings at the end of the lifecycle in the absence of depreciation of human capital. Also the total value of the time endowment is plotted ($WH(t)$). This is a measure for total labor productivity, since rental rates are constant over time. It peaks at age 46, before the peak in earnings, cf. Ben-Porath (1967) and Heckman (1976). The intuition is that individuals are still investing about 10% of their time endowment in OJT at that age. Consequently, total labor productivity peaks earlier in the lifecycle than total earnings do. The individual also has a valuable time endowment after retirement, although it is steadily depreciating. Investment in human capital drops to zero at retirement, since the marginal value of investment in human capital has become zero at that date. Finally, the lifecycle path of consumption is increasing. The reason is that the net interest rate is larger than the pure rate of time-preference.

Interesting wealth dynamics emerge from our model, see Figure 2. Like in any lifecycle model, total wealth, defined as the present discounted value of remaining life-time consumption, declines continuously with age until it becomes zero at the end of life. In contrast to

[2]Gruber and Wise (1999) report the so-called 'tax force' statistic, which corresponds to the sum of marginal tax wedges on retirement while working during ages 55–69. Dividing the 'tax force' by 15 gives a yearly average marginal tax wedge on retirement during working ages 55–69. OECD (2004) computes marginal tax wedges on retirement which are around 20% (40%) on average for 55-59 (60-64) year old workers. Duval (2004, p.33) calculates that average implicit tax rates in OECD countries are equal to 30%.

[3]Implicitly, we assume public goods enter in a completely separable fashion in the utility function.

Figure 1:


Labor earnings, consumption, OJT-investment and human capital over the life-cycle
W(t)(1-l(t))H(t)
W(t)l(t)H(t)
W(t)H(t)
C(t)
Age
0
5
10
15
20
25
30
35
40
45
50
20
25
30
35
40
45
50
55
60
65
70
75
80

models with exogenous human capital, financial wealth drops to negative levels at the beginning of the lifecycle while the individual is investing in OJT. The evolution of life-time financial wealth shows that capital markets to smooth consumption over the lifecycle could be important, although borrowing is not that large at the beginning of the lifecycle. Indeed, most of the financial wealth is accumulated after 45 years of age to finance consumption during the retirement phase. The evolution of human wealth is the mirror image of the evolution of financial wealth. Human wealth increases in the initial years when the individual is investing in OJT. Human wealth steadily decreases while working as the remaining life-time earnings diminish. At the moment of retirement, human wealth has become negative reflecting the value of forgone labor earnings while the individual is retired. Human wealth starts rising again towards the end of life as forgone earnings from retirement decrease to zero at the end of life.

Figure 3 plots the simulated patterns of OJT-investment and lifecycle earnings for different values of the labor tax rate and the capital tax rate. Life-cycle investments in OJT are affected by the labor tax rate through its impact on retirement only (recall that all costs of OJT are deductible). Since retirement is distorted by the presence of the implicit tax $\tau_R$, a higher explicit tax on retirement $\tau_L$ reduces OJT-investments to a considerable extent, because the payback period of investment in human capital falls. As a result, lifecycle earnings profiles shift towards the origin. Since OJT-investments fall, the peak of earnings will be earlier. Moreover, since less time will be invested in OJT, earnings when young increase slightly. However, at later ages this is more than offset by lower stocks of human capital so that earnings fall at later ages. This, in turn, makes retirement more attractive, since opportunity costs of retirement are lower as wages in the last year working have fallen. This graph indirectly shows that policies which stimulate earlier retirement, can have important consequences for OJT investments. We return to this below.

A higher capital tax boosts investments in human capital, since saving becomes less attractive compared to investment in OJT. Again we see the rotation of earnings-profiles as under the labor tax, but now in the reverse direction. Especially, at the beginning of working careers, OJT-investment increases, hence total gross labor earnings fall. Over time, however, this fall in earnings will be compensated by rising levels of human capital which causes a rise in earnings. The peak in the earnings profile shifts to later ages and individuals end their working careers with substantially higher earnings. This graph demonstrates the fundamental interactions between saving policies and OJT-investments. Indeed, human capital investments in OJT can be seriously affected if governments want to boost saving by lowering the capital tax (or even give tax-incentives for saving). Consequently, OJT-policies cannot be seen in isolation from pension and saving policies.

Figure 4 plots the investment and earnings profiles for various implicit tax rates on retirement and depreciation rates of human capital. A higher implicit tax on retirement $\tau_P$, much like the labor tax, gives stronger incentives to retire early from the labor market. Indeed, investment in human capital falls during all ages. This increases earnings temporarily as workers have higher labor earnings at the beginning of the lifecycle, but their wage growth over the lifecycle will be substantially lower. Consequently, workers end up with lower wages at the end of their career, as their human capital stocks will be much lower. This makes retirement also more attractive as

Figure 2:

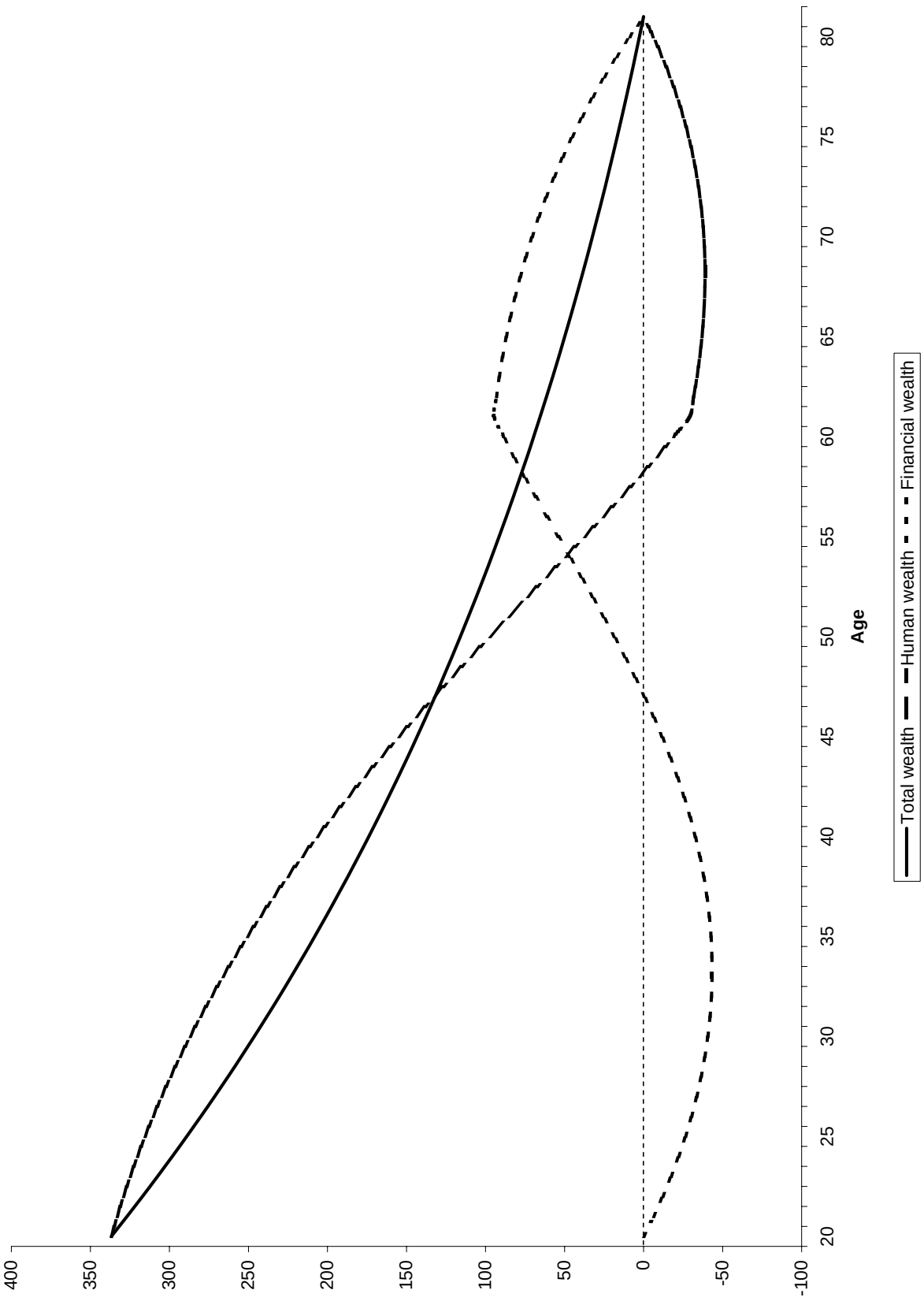
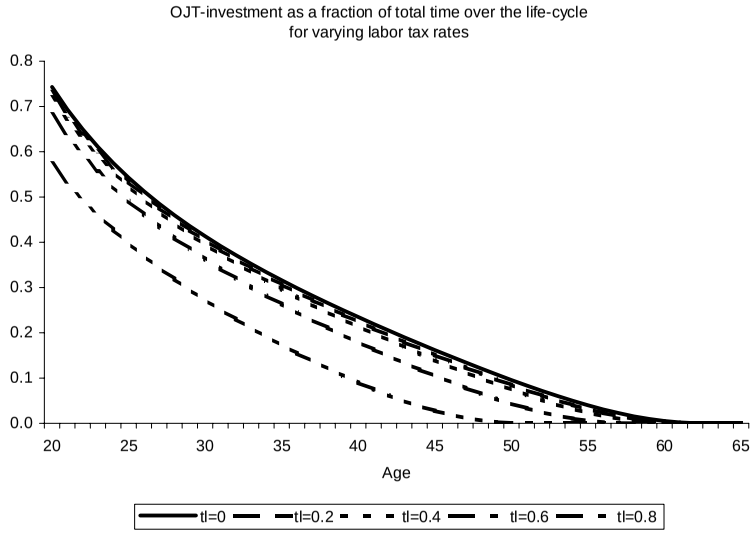
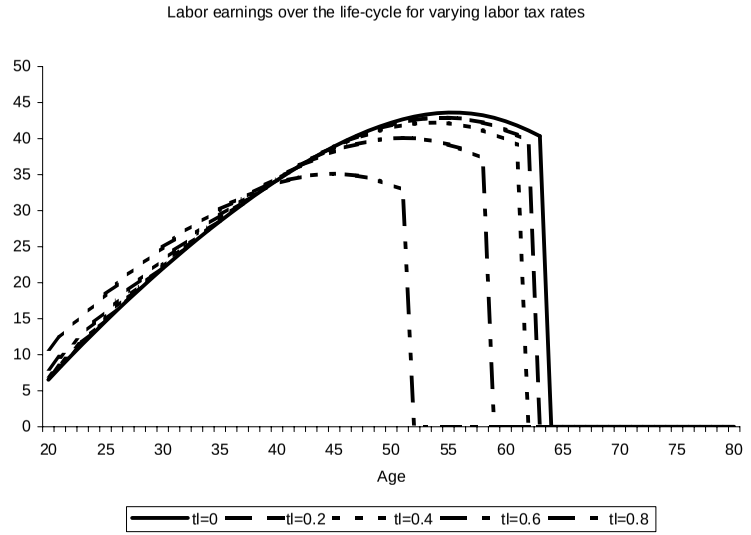
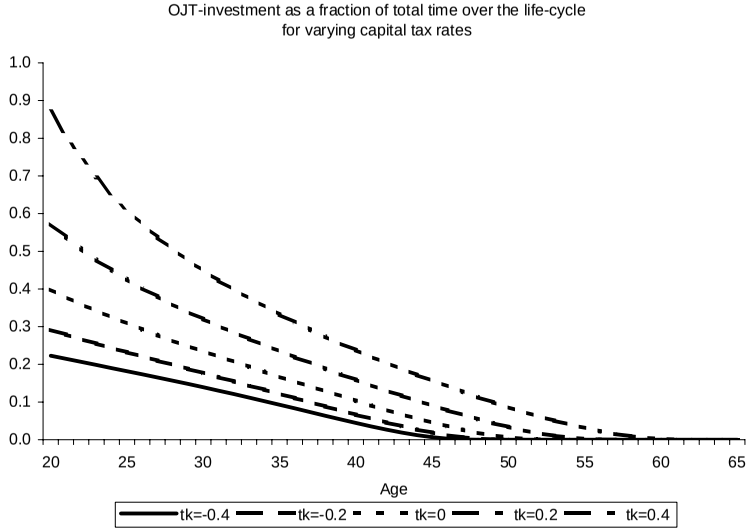
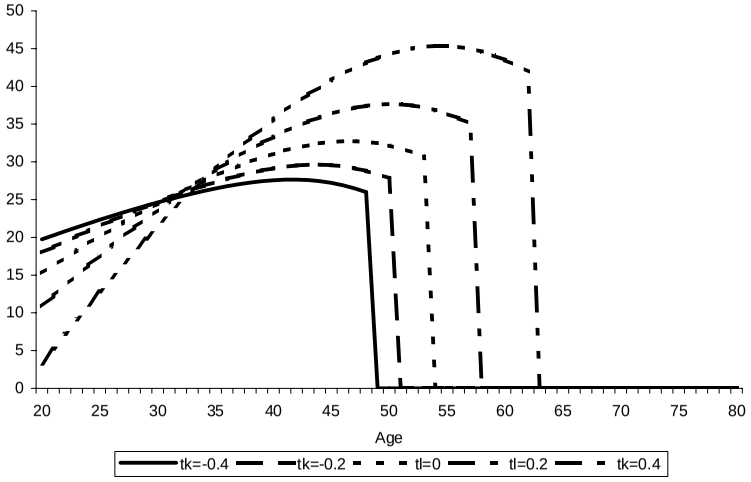

Total, human, and financial wealth over the life-cycle
400
350
300
250
200
150
100
50
0
-50
-100
20
25
30
35
40
45
50
55
60
65
70
75
80
Age
Total wealth
Human wealth
Financial wealth

Figure 3:


OJT-investment as a fraction of total time over the life-cycle
for varying labor tax rates
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20 25 30 35 40 45 50 55 60 65
Age
tl=0 tl=0.2 tl=0.4 tl=0.6 tl=0.8


Labor earnings over the life-cycle for varying labor tax rates
50
45
40
35
30
25
20
15
10
5
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
tl=0 tl=0.2 tl=0.4 tl=0.6 tl=0.8


OJT-investment as a fraction of total time over the life-cycle
for varying capital tax rates
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20 25 30 35 40 45 50 55 60 65
Age
tk=-0.4 tk=-0.2 tk=0 tk=0.2 tk=0.4


Labor earnings over the life-cycle for varying capital tax rates
50
45
40
35
30
25
20
15
10
5
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
tk=-0.4 tk=-0.2 tl=0 tl=0.2 tk=0.4

the opportunity costs of retirement have fallen. Thus, when retirement schemes are actuarially very unfair, and thereby cause large distortions on retirement, this seriously impairs investments in OJT too. As a result, our theoretical model confirms the notion that individuals do not invest in skills because they retire early, and they retire early because they do not invest in skills.

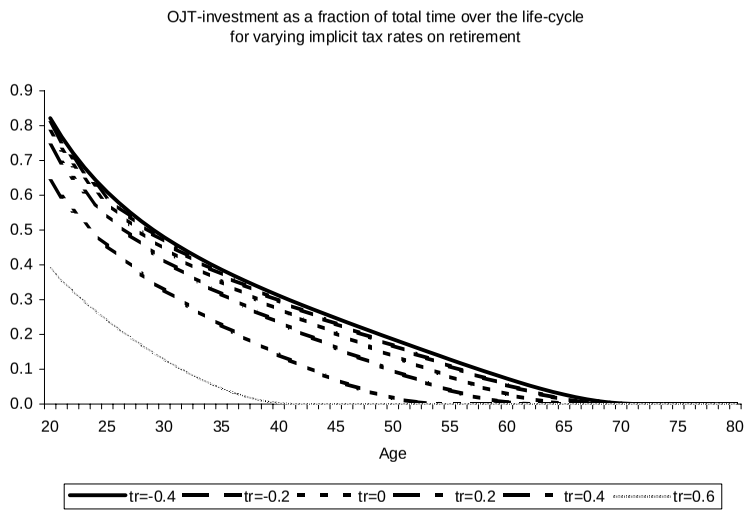
A larger rate of depreciation of human capital has similar effects as a higher implicit tax on retirement, only the consequences of higher depreciation rates are more severe. Indeed, the higher depreciation rate makes saving in financial capital relatively more attractive at all times, hence investments in human capital fall throughout the lifecycle. Indeed, at relatively modest depreciation rates (6% and higher), earnings profiles even become downward sloping over the lifecycle.

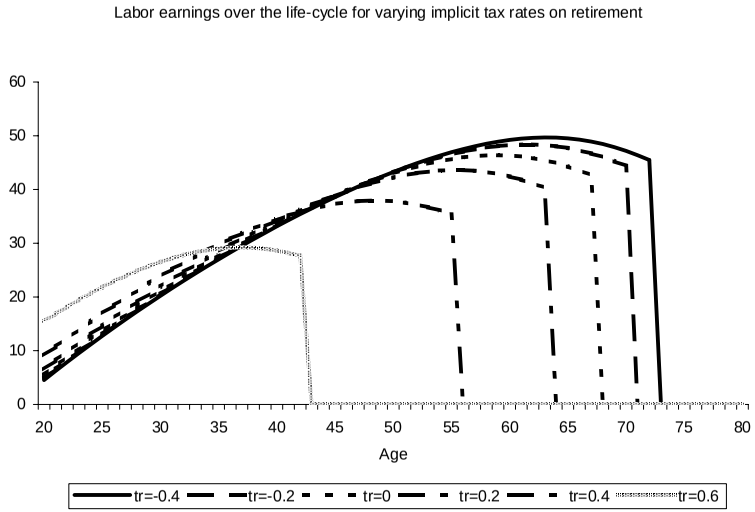
The messages from the retirement-augmented Ben-Porath model are clear-cut and simple. Investment in OJT shifts the wage profiles upwards, which implies that there are positive returns to OJT-investments. Investment in OJT increases if the retirement date increases (lower explicit and implicit taxes on retirement), if the opportunity return on saving decreases (higher capital taxes) and if the depreciation rate is lower. The lifecycle earnings profile is typically 'hump-shaped'. Moreover, policies that boost investment in human capital depress earnings at the beginning of the lifecycle and boost earnings at later ages. This is because the cost of investment is forgone working time. The model finally demonstrates that the policy environment is critical to understand lifecycle patterns in OJT-investment, labor earnings, retirement ages and savings behavior. Indeed, financial saving and human capital investments are substitutes, whereas retirement and human capital investments are complements.

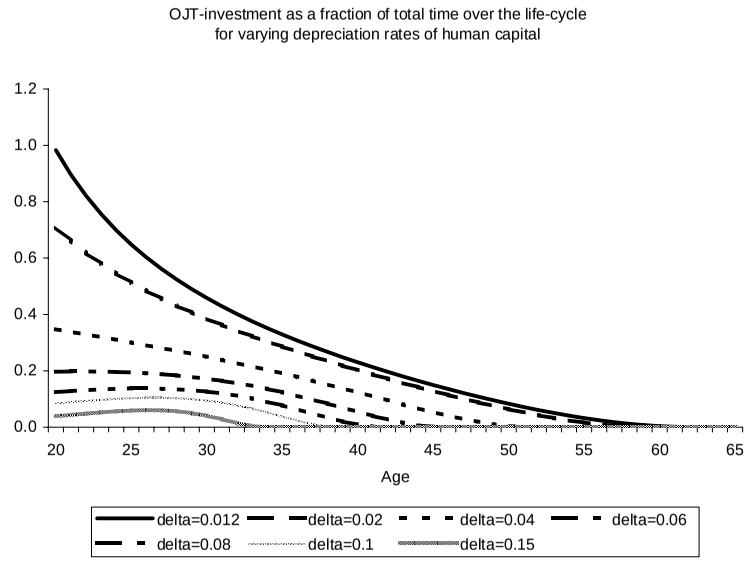
Although the parameters of the model are not completely unrealistic, we still should be careful in drawing quantitative conclusions. All simulations are driven by the particular assumptions on the intertemporal elasticity of substitution in consumption $\theta$, the elasticity of the human capital production function $\alpha$, and the retirement elasticity $\beta$. Figures 5 and 6 provide some sensitivity analyses on the main elasticities of the model. The consumption and retirement elasticities are indeed important for retirement choices. Slight differences in both give quantitatively large impacts on the retirement decision. This is in main part driven by the fact that retirement choices are severely distorted. Indeed, the total tax wedge on retirement equals $1-(1-\tau_L)(1-\tau_R)=0.65$. Consequently, relatively small changes in elasticities have large impacts on retirement choices. The impacts on retirement choices should therefore be handled with care, given the relatively high value of $\theta$ we assumed in the base-line simulations so as to avoid backward-bending retirement curves. Not surprisingly, the elasticity of the human capital production function determines to an important extent the behavioral response of OJT-investments over the lifecycle. However, the lifecycle profile of wages is not so much affected. It only flattens out a bit over time. Note that we could not increase $\alpha$ a lot, since the non-negativity constraint on working time would then become binding.

Finally, we simulated the model for different productivity levels of human capital $B$. We find that a higher productivity in OJT-investments (e.g. due to more initial education) unambiguously raises later OJT-investments. Initial earnings fall because individuals with a larger $B$ spend a larger fraction of time to human capital investment, but earnings at later stages of the lifecycle increase as a result of more human capital accumulation.

Figure 4:


OJT-investment as a fraction of total time over the life-cycle
for varying implicit tax rates on retirement
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
tr=-0.4 tr=-0.2 tr=0 tr=0.2 tr=0.4 tr=0.6


Labor earnings over the life-cycle for varying implicit tax rates on retirement
60
50
40
30
20
10
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
tr=-0.4 tr=-0.2 tr=0 tr=0.2 tr=0.4 tr=0.6


OJT-investment as a fraction of total time over the life-cycle
for varying depreciation rates of human capital
1.2
1.0
0.8
0.6
0.4
0.2
0.0
20 25 30 35 40 45 50 55 60 65
Age
delta=0.012 delta=0.02 delta=0.04 delta=0.06
delta=0.08 delta=0.1 delta=0.15

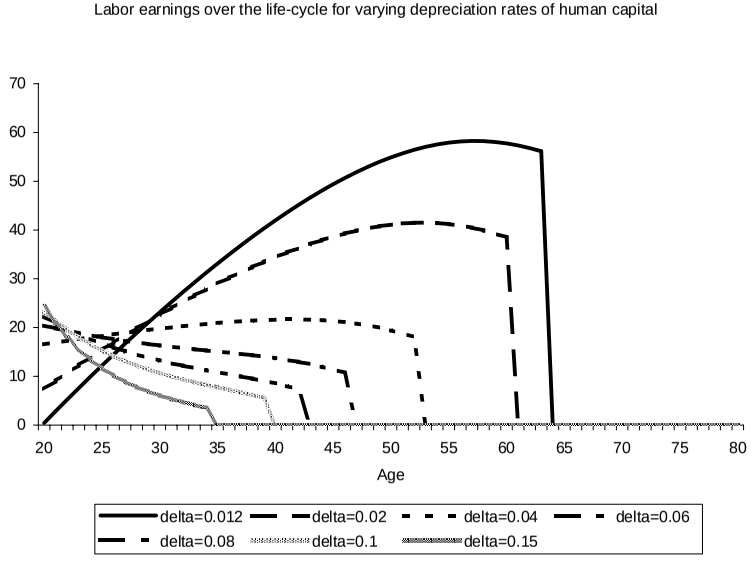
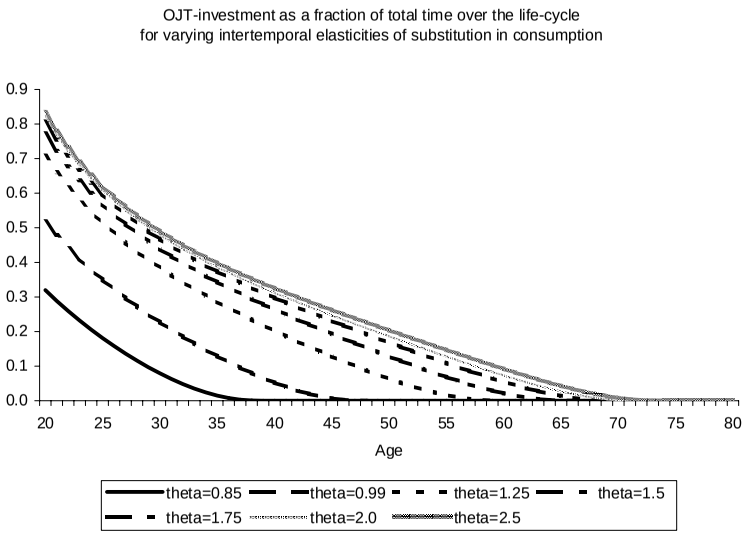
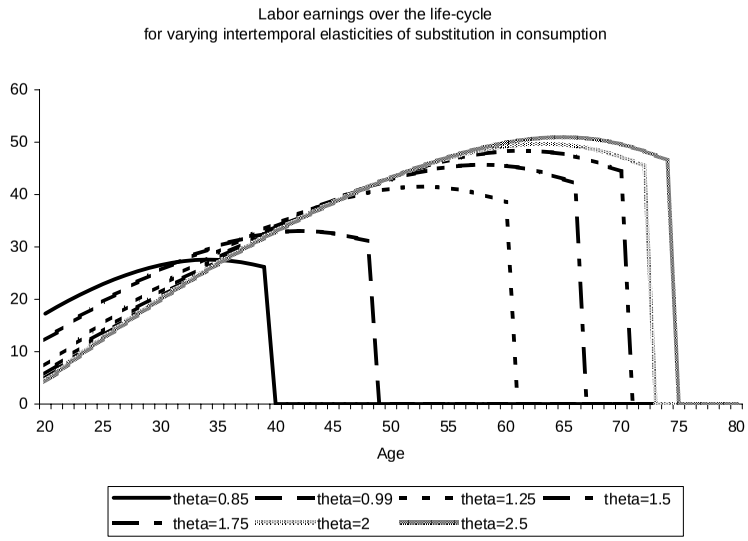
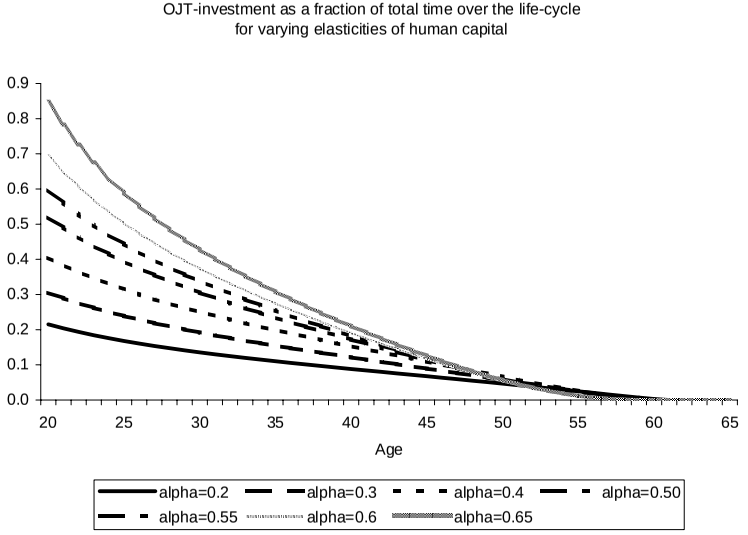

Labor earnings over the life-cycle for varying depreciation rates of human capital
70
60
50
40
30
20
10
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
delta=0.012 delta=0.02 delta=0.04 delta=0.06
delta=0.08 delta=0.1 delta=0.15

Figure 5:


OJT-investment as a fraction of total time over the life-cycle
for varying intertemporal elasticities of substitution in consumption
Age
theta=0.85
theta=0.99
theta=1.25
theta=1.5
theta=1.75
theta=2.0
theta=2.5


Labor earnings over the life-cycle
for varying intertemporal elasticities of substitution in consumption
Age
theta=0.85
theta=0.99
theta=1.25
theta=1.5
theta=1.75
theta=2
theta=2.5


OJT-investment as a fraction of total time over the life-cycle
for varying elasticities of human capital
Age
alpha=0.2
alpha=0.3
alpha=0.4
alpha=0.50
alpha=0.55
alpha=0.6
alpha=0.65

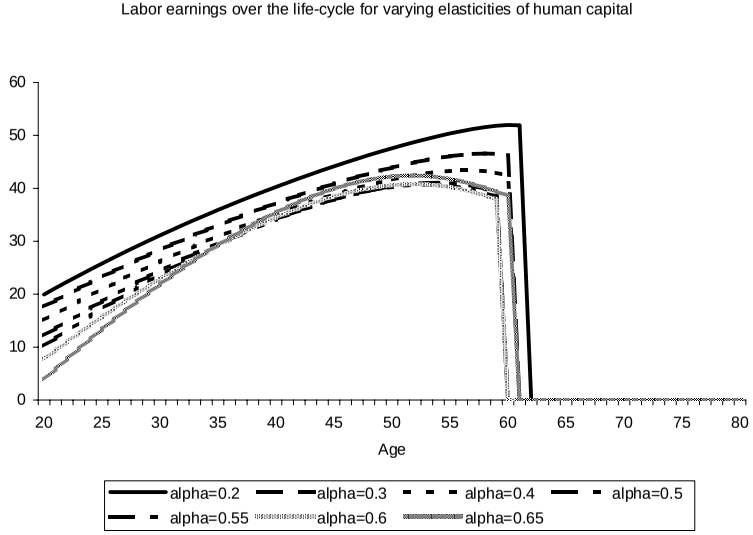
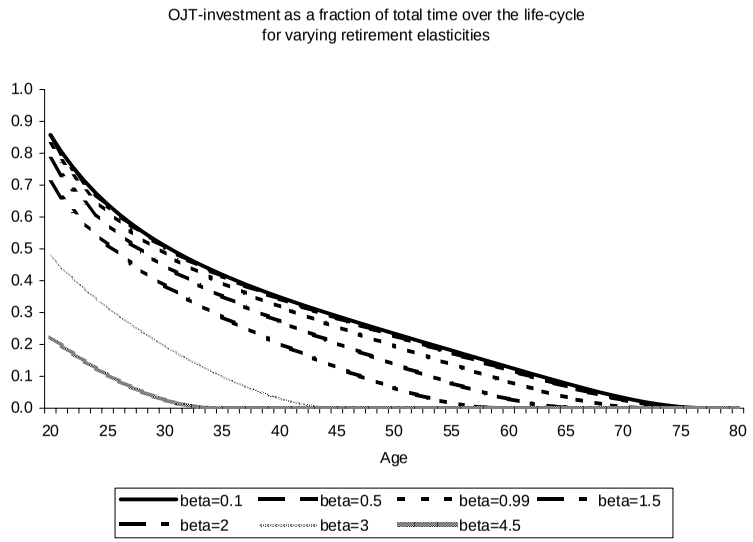
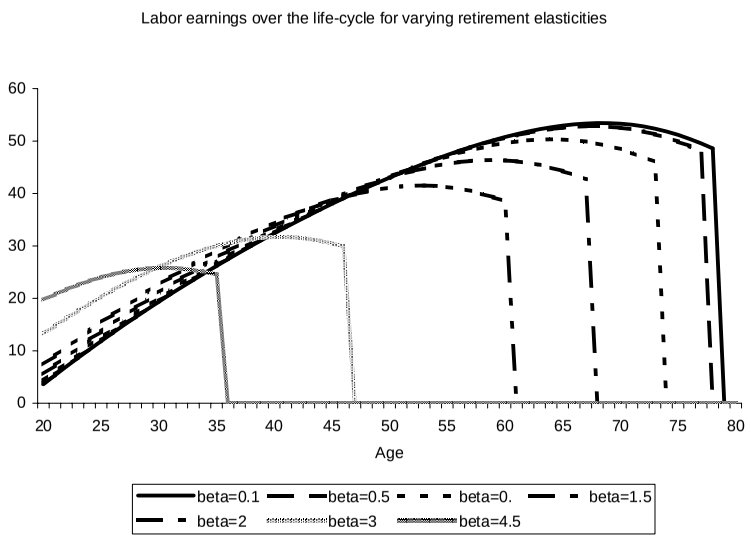
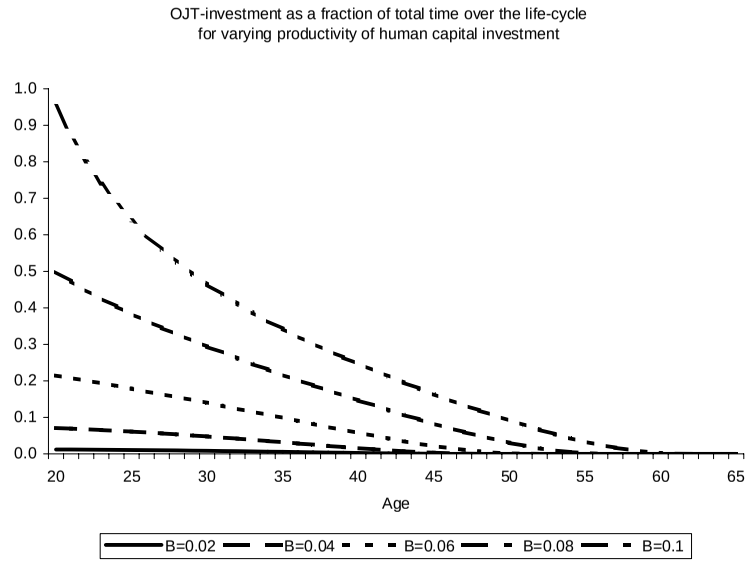
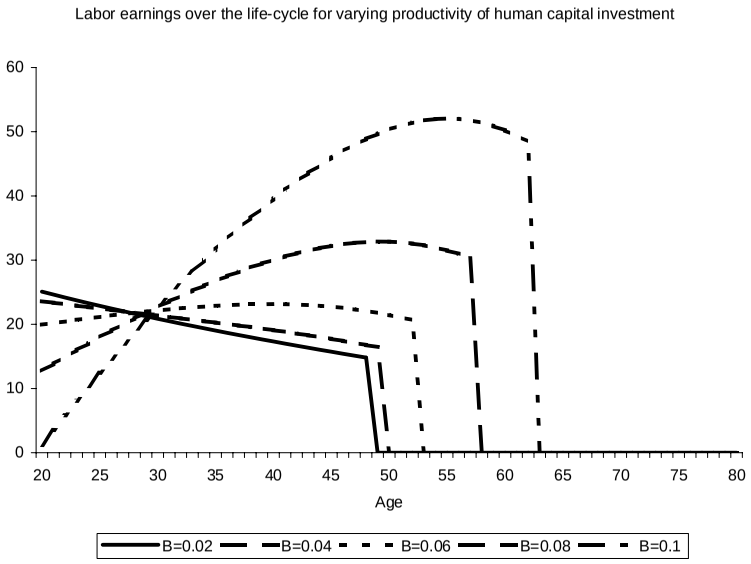

Labor earnings over the life-cycle for varying elasticities of human capital
Age
alpha=0.2
alpha=0.3
alpha=0.4
alpha=0.5
alpha=0.55
alpha=0.6
alpha=0.65

Figure 6:


OJT-investment as a fraction of total time over the life-cycle
for varying retirement elasticities
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
beta=0.1
beta=0.5
beta=0.99
beta=1.5
beta=2
beta=3
beta=4.5


Labor earnings over the life-cycle for varying retirement elasticities
60
50
40
30
20
10
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
beta=0.1
beta=0.5
beta=0.
beta=1.5
beta=2
beta=3
beta=4.5


OJT-investment as a fraction of total time over the life-cycle
for varying productivity of human capital investment
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20 25 30 35 40 45 50 55 60 65
Age
B=0.02
B=0.04
B=0.06
B=0.08
B=0.1


Labor earnings over the life-cycle for varying productivity of human capital investment
60
50
40
30
20
10
0
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
B=0.02
B=0.04
B=0.06
B=0.08
B=0.1

# 4 Empirical content of the model

## 4.1 Earnings-profiles and OJT

The empirical evidence is roughly in line with the stylized features of the model outline above. Age-earnings profiles ($W(1 - I(t)H(t))$ are indeed hump-shaped, which follows from the commonly estimated Mincer equation with experience (age) and experience squared (age squared) (see e.g. Card, 1999). Direct measurements of productivity over the lifecycle are indeed quite suggestive of a hump-shaped pattern of productivity of the lifecycle as well. Skirbekk (2005) surveys the literature and finds the following stylized facts. Cognitive abilities decline after some stage in adulthood. Older workers compensate withering cognitive skills with sufficient working experience (for example by OJT or learning-by-doing). Based on subjective evaluations of managers, age-productivity profiles do not seem to display systematic patterns. Evaluations by workers suggest that worker's productivity indeed falls with age. Objective evaluations (based on measured outputs) suggests that quantity and quality of output show a hump-shaped pattern with age. Importantly, as predicted by our model labor productivity peaks before earnings.

However, from the hump-shaped pattern of earnings one cannot conclude that they are *caused* by investments in OJT. Indeed, other theories of wage determination over the lifecycle could be relevant too (incentives, learning by doing, wage setting institutions, etc.). Also Skirbekk (2005) resorts to Lazear's (1976) theory of work-incentives over the lifecycle. These are discussed in more detail below.

Direct estimates of the effect of training activities on wages generally give positive wage returns (Leuven, 2005; Bassanini et al., 2006). Allocating time to training activities thus raises wages over the lifecycle. However, the empirical evidence also seems fragile due to selectivity problems in the estimations (Leuven, 2005; Bassanini et al., 2006). Moreover, some serious measurement issues prevent drawing strong conclusions, see below.

## 4.2 Time-horizon and complementarity with initial education and OJT

Given the finite horizon ($T$), younger workers are expected to participate more in training. Furthermore, better educated workers (higher $B$) are also expected to invest more in training, since training increases with the productivity of training activities. Both are indeed found to be stylized facts in the data (Leuven, 2005; Bassanini et al., 2006).

## 4.3 Participation and OJT

Another stylized fact is that male workers have higher participation rates in training than female workers. One obvious explanation is that men work more hours and have higher labor participation. Consequently, their 'utilization rates' of OJT human capital are higher. Given that our model does not allow for an endogenous work/participation decision, we miss this feature. However, Heckman and Jacobs (2006) extend a similar model with endogenous labor supply and find that workers with less labor supply utilize their human capital less and therefore invest less in OJT.

### 4.4 Retirement and OJT

The age of retirement also constitutes an important element of the utilization of human capital over the lifecycle. At retirement, human capital is written off completely. Labor force attachment of the average worker is rapidly declining with age. This development is also carefully documented by Gruber and Wise (1999).

Many workers retire long before statutory retirement ages via all kinds of early-retirement schemes. Pension benefits can be generous as well. Pension replacement incomes in Continental European are quite high and about 60-80% of pre-retirement earnings for an average worker (OECD, 2005). Pension systems are PAYG state pensions almost everywhere. Exceptions are the Anglo-Saxon countries, the Netherlands, Sweden and Denmark that also heavily rely on substantial private funding, either through DB/DC occupational pensions or individual saving schemes see also OECD (2005).

It is not easy to make international comparisons because the institutional details vary from country to country. Gruber and Wise (1999) summarize the impact of early retirement schemes on the labor market by the implicit marginal tax rates imposed on an additional year of work (our $\tau_R$). Duval (2004) and OECD (2004) demonstrate that early retirement schemes do indeed cause very high marginal tax rates on pre-retirement incomes. Moreover retirement ages and benefit generosity are very negatively related. Gruber and Wise (1999, 2002) present strong evidence that this is a causal relation. In recent years some countries have attempted to reform their pension schemes. The Netherlands, Germany, France, and Italy are examples.

Bassanini et al. (2006) do a simple cross-country panel analysis, which suggests that investments OJT and later retirement are indeed positively correlated. This is consistent with our findings. Moreover, skilled workers typically retire much later than unskilled workers (OECD, 2006). Since education and training are complementary activities, this should come as no surprise either.

### 4.5 Pensions

At least theoretically, saving and investing in human capital appear to be substitutes as the model predicts. However, not much is known about the impact of saving or pension policies ($\tau_A$) on the incentives for OJT-investments. Clearly, tax incentives are important for saving decisions (see e.g. Bernheim, 2002). As of today, there appears to be no empirical evidence that directly estimates the impact of saving and pension policies on OJT-investment.

## 5 Theoretical, empirical and methodological issues

Is the model presented above the correct model to analyze the interactions between human capital, retirement and pensions? We don't know for various reasons. First of all, maybe the standard human capital model is not the right model to capture lifecycle earnings. Various competing theories are available. Second, both measurement and methodological issues prevent the direct testing of the model. These issues will now be discussed in more detail.

## 5.1 Measurement of investment and returns

Investment in OJT (flow) or the human capital (stock) are quite difficult to measure. Both are not easily directly verifiable to the econometrician. Indeed, Heckman (2000) and Carneiro and Heckman (2003) argue that most training is informal, rather than formal. This fundamental non-verifiability of OJT-investments severely limits the applicability of commonly employed training measures, which are often based on subjective data (firms or employees) on formal investment in OJT. Generally dummy-variables are employed in regression analyses that indicate whether workers have participated in (some) training. Moreover, the intensity of training is not always known with much precision. Further, firms and employees seem to have different views on the participation/intensity of training. See also Leuven (2005) for an elaborate review.

Not only the costs (i.e. the investment in OJT), but also the returns (future) wages are difficult to measure empirically. The reason is that earnings are not equal to productivity, since time-investment needs to be subtracted from gross labor productivity to obtain gross labor earnings. Clearly, time costs are the most important ingredient of total investment in human capital (Mincer, 1958, 1962; Schultz, 1963; Becker, 1964; Trostel, 1993). Note that this is true even in perfectly competitive labor markets – something that is often overlooked (see, for examples, Skirbekk, 2005, p16-18; Bassanini et al. 2006, p. 9).

Worker productivity is difficult to measure precisely – even if wages are fully informative – since the total investment in human capital cannot be verified. Hence, the returns to OJT are quite difficult to measure as a result. Heckman et al. (1998) do obtain estimates, however, by identifying skill prices per unit of human capital from the earnings of the older workers who are in their latest years of their careers. Indeed, human capital investments would approximately be zero for these workers, so that labor earnings indeed reflect productivity if depreciation rates are zero. The latter cannot easily be measured, but Heckman et al. (1998) argue that, since wages typically do not decline at later ages, depreciation rates should be approximately zero as well. Hence, skill prices can be identified from the wages of older workers.

Another important assumption – present in all OJT-theories above, including Heckman et al. (1998), is that workers with different vintages of OJT human capital are perfect substitutes in production, so that rental rates per unit of human capital are equalized across all individuals with different levels of OJT human capital. At first sight, it would seem implausible that this would indeed be the case. However, any empirical evidence on these matters is currently lacking.

## 5.2 Imperfectly competitive labor markets and OJT

We abstracted from market frictions in the model above and assumed that the rental rate $W$ is equal to the productivity per unit of human capital. Moreover, we assumed it was constant over the lifecycle. However, in non-competitive labor markets the theoretical connection between productivity and labor earnings is lost – even if we could correctly measure all investment costs. Wages, or more precisely, rental rates per unit of human capital do then not purely reflect productivity, but also market frictions. Moreover, the rental rates do not need to be constant over the lifecycle.

### 5.2.1 Minimum wages

A wage floor in an otherwise competitive labor market destroys employment for all workers with labor productivity below the wage floor which results in involuntary unemployment among these workers. Wage floors increase the wages of unskilled workers relative to skilled workers. Consequently, incentives to invest in OJT diminish. In addition, the employment probabilities of low skilled workers diminish and incentives to become skilled improve. Minimum wages may also generate general equilibrium effects on the wage structure by changing relative supplies of workers (Teulings, 2003). Hence, the effect of wage floors on skill formation is ambiguous.

### 5.2.2 Unions, efficiency wages, frictions, and insiders-outsiders

In a wide class of models with unions, efficiency wages, search frictions or insider-outsider problems, equilibrium wages are typically characterized by a mark-up equation relating the equilibrium wage to the outside options of workers, see Booth (1995), Mortensen and Pissarides (1999), Akerlof and Yellen (1986), and Lindbeck and Snower (1998, 2002). Equilibrium unemployment results because wages are pushed above the market clearing level. The wage mark-up generally increases with a larger bargaining power of workers, a lower elasticity of labour demand, a higher replacement rate, lower marginal and higher average income tax rates, higher firing costs, and better employment protection. See Layard et al. (1991), Pissarides (1998), Sørensen (1999), Lindbeck and Snower (2002), Bovenberg (2006), and Van der Ploeg (2006), and others.

One might be tempted to conclude that in non-competitive labor markets, investments in OJT will be reduced as wages (the main cost of the investment) will be driven above market-clearing levels. Hence, investing in human capital becomes less attractive. However, also here some individuals will be priced out of the labor market and become unemployed/inactive. Employment rates are indeed much higher among the better skilled workers and better skilled individual retire much later (OECD, 2006). Therefore, investment in OJT might also be boosted in non-competitive labor markets if workers want to lower the probability of becoming unemployed or inactive. As a result the impact of labor market institutions on OJT appears to be ambiguous from a theoretical perspective.

Labor market frictions will not only have static effects, but also affect the wage structure over the whole lifecycle. Employment protection legislation typically protects the older workers better than the younger workers. Labor turnover costs increase with workers' experience due to higher firing costs, stricter employment protection legislation, seniority rules ('last in, first out'), and other terms of employment. Older workers may have more bargaining power than younger workers, which could be relevant for union, search and insider-outsider explanations. Typically, entitlements to social benefits increase with work experience and with income. So it would be fair to argue that outside options become more valuable as workers get older. All theories on non-competitive labor markets (unions, search frictions, efficiency wages, insiders-outsiders) then imply that wages are pushed more above market clearing levels as workers age. The actual design of labor market policies, tax systems and social benefits is therefore critical in understanding how the outside options of workers are affected over the lifecycle (see Bovenberg and Van der Ploeg, 1994). Most analyses in the training literature pay insufficient attention to

the tax treatment of both earnings and outside options, how entitlements to benefits are build up over time, and whether benefits are related to final earnings, and so on.

### 5.2.3 Dynamic incentives

Also in Lazear's (1976, 1979, 1981) theories work incentives, mandatory retirement and hours-restrictions the wage profile rotates. By changing the earnings over the lifecycle, the firm can provide incentives to workers if workers' productivity levels cannot be observed by the firm. Typically, an optimal contract features lower wages than labor productivity at the beginning of the lifecycle and higher wages than labor productivity at the end of the lifecycle. As such, also incentive issues can explain a hump-shaped pattern of earnings over the lifecycle. Given the above market-equilibrium wage at the end of the lifecycle it is optimal to have mandatory retirement (Lazear, 1979). And, given that wages are not constant across years, it is optimal to have hours restrictions to avoid welfare losses of distortions in labor supply (Lazear, 1981).

### 5.2.4 Tilting wage profiles affect incentives for OJT

If the wage profile indeed tilts in favour of older workers, due to labor market frictions, institutions, or incentive schemes, the incentives to invest in schooling and training can be considerably affected. Older workers face weaker incentives to maintain skills and will invest less in second careers because the opportunity costs of doing so increase. Therefore, younger workers have strong incentives to invest in their careers early. The tilting of the wage profile can promote steeper depreciation of human capital over the lifecycle. Incentives to retire early increase and employment rates of older workers decrease. See also the model simulations in the previous section. This is not necessarily efficient, and may be costly in terms of labour supply. As a corollary to Lazear (1979, 1981) binding limits on training for younger workers and forced OJT programs for older workers could be optimal when the wage profile is used to provide work incentives over the lifecycle. This is a conjecture, however.

### 5.2.5 Empirical evidence non-competitive labor markets and OJT

The direct evidence on the effect of labor market imperfections on training is rather inconclusive (Bassanini et al., 2006). There indeed appears to be some evidence that increased opportunity costs (e.g. due to minimum wages) reduces investments in OJT. However, most empirical testing typically suffers from sample attrition biases. The reason is that more productive workers have positively selected into jobs, whereas unproductive workers would have become unemployed and vanish from the data samples being analyzed. Empirical testing of different labor market settings is therefore problematic. Moreover, institutions are slowly varying over time and the econometrician has to rely on cross-sectional differences to identify the effects. However, allowing for country specific effects virtually always destroys any cross-sectional correlations found (see e.g. Heckman and Pages, 2003). Moreover, estimates relying on the cross-sectional dimension could be biased due to cohort effects. Ideally panel-data are needed to identify lifecycle impacts, but this is not often done.

### 5.2.6 Monopsony

Both non-competitive labor markets and dynamic incentives could result in the wage distributions that will not be 'compressed', but 'decompressed' over the lifecycle, since earnings at the end of the lifecycle decrease and at the beginning of the lifecycle increase. This contrasts sharply with many modern training theories that emphasize the monopsonistic nature of labor markets (see Acemoglu and Pischke, 1998; 1999). Like the literature on minimum-wages in monopsonistic labor markets (cf. Manning, 2003), this line of research essentially argues that wages are driven *below* productivity levels by firms that exert monopsonistic or oligoponistic wage setting powers. Consequently, firms may even pay for general training, which contrasts with Becker (1964). The intuition is that productivity of workers increase faster than the wages the firm will pay.

Since the labor market is typically inefficient due to wages that are set below labor productivity, minimum wages, unions and other wage-increasing mechanisms may in fact be second-best optimal. Monopoly-like behavior on the labor supply side is a countervailing power to monopsonistic behavior of firms so that wages can be better aligned with labor productivity, see for example Booth and Chatterji (1998) and Acemoglu and Pischke (1999, 2003).

### 5.2.7 Empirical relevance monopsony theories

An important empirical issue is whether wages (or, more precisely, rental rates of human capital) would indeed be driven *below* market-clearing levels and more so for better trained workers. All unemployment or under-utilization of human capital would then be voluntary. Moreover, a 'compressed' wage distribution would not only increase employment, but also boost investment in human capital. A priori this seems hard to believe given the apparent lack of skills of many workers who (involuntary) end up as being unemployed.

Welfare state interventions are indeed associated with compressed wage structures (Freeman and Katz, 1995; Blau and Kahn, 1996; Gottschalk and Smeeding, 1997). At the same time, corporatist countries with stronger labor market regulations and more extensive welfare states appear to have more steeply increasing age-earnings profiles compared to the countries with more competitive labor markets (Brunello, 2000). Hence, lifecycle earnings profiles 'de-compress', rather than 'compress' due to various labor market interventions. It is therefore important to distinguish between age-earnings profiles and cross-sectional wage-distributions. Cross-sectional wage distributions can indeed be compressed, but age-earnings profiles need not.

The other side of the same coin is that non-employment is much higher in countries with 'compressed wage structures' in comparison with countries that have more competitive labor markets. Wages are probably raised above market-clearing levels in corporatist labor markets especially at the low-end of the wage distribution and for older workers given the much larger prevalence of non-employment among these groups. Monopsony-based theories have a hard time explaining this feature of the data. Indeed, if this were the correct description of labor market imperfections, employment rates, especially among the older workers, would be much higher than for the younger workers, since firms extract more monopsony-rents from the older than younger workers as they accumulated more human capital through OJT. Monopsony-based labor training theories could therefore be a red herring empirically.

### 5.3 Specific investments

Not all OJT-investment is general as already stressed by Becker (1964). Some investments in human capital are specific to the employer-worker relationship. If the labor market is perfectly competitive, the firm pays for all costs and benefits of the investment. This provides an explanation why firms seem to pay for most OJT-investments of workers (Bassanini et al. 2006). Since the firm is the residual claimant of the specific investment, one could say that the firm 'owns' all specific human capital. The worker just receives the spot wage rate in the labor market that would be obtained without any specific investments (see also Leuven, 2005). As a result, firm-specific investments in human capital cannot explain the hump-shaped age-earnings profiles. If the spot wage rate would be flat – as we assumed in the model above – then the labor earnings profile would be flat too. More generally, in partial equilibrium specific investments would typically flatten age-earnings profiles, which goes in the opposite direction of explaining the hump-shape in earnings.

With specific investments in human capital, labor earnings must be higher than labor productivity at the beginning of the lifecycle and lower than labor productivity at later stages of the lifecycle if specific human capital is accumulated. The intuition runs as follows. Perfect competition between firms ensures that profits are driven down to zero in equilibrium. Moreover assuming perfect mobility across jobs, the present value of earnings in a job with specific investments in human capital must be equal to the present value of a job without specific investments to attain equilibrium in the labor market. Thus, as long as labor productivity increases over time, the job with more investment in specific human capital pays higher wages than productivity at the beginning of the lifecycle and higher wages than productivity at the end. Empirically, it is therefore not clear whether specific investments in human capital can go a long way in explaining age-earnings profiles and relatively employment levels of older workers. Indeed, firms would find older workers attractive as the pay them less than their productivity. It is also practically difficult for the analyst to distinguish specific from general training.

Moreover, it is not so clear whether firms really pay for most of the costs of OJT, once the general equilibrium feedbacks in the labor market have been taken into account. Indeed, the workers may pay for the investments by accepting a lower earnings-profile in a job with a lot of specific OJT-investment. Most empirical analyses abstract from these general equilibrium feedbacks.

Only if labor turnover is introduced into models of specific investments, both workers and firms typically share the costs and returns to the investment in human capital. The intuition is that the firm does not find it attractive to invest in specific investments if there is a probability that the worker will quit the firm. Then, wages will be increasing over the lifecycle. However, the presence of exogenous labor turnover must be due to some form of contract incompleteness or some form of market friction. For example, it is generally impossible for firms to claim part of the wages of workers after quitting the firm. Alternatively, there can be various sources of asymmetric information or differences in bargaining power between the employee and the firm. As a result, various types of hold-up problems emerge which may result in inefficient levels of OJT-investment and inefficient quits (Hashimoto, 1980; Leuven and Oosterbeek, 2001; Leuven, 2005). The empirical implications of specific OJT are similar to those of the monopsony

models. Indeed, monopsony power is also driven by specificity in worker-employer relationships (Acemoglu and Pischke, 1998; 1999). See also the discussion above.

### 5.4 Learning-by-doing

Wage profiles might not be generated by OJT, but by learning-by-doing (LBD). The basic idea is simple. As long as workers are employed, they accumulate work experience. Since older workers accumulated more work experience, their productivity levels will be higher, and – in competitive labor markets – their wages will rise over the lifecycle. The distinguishing feature of learning by doing models is that there is no trade-off between current and future earnings as in the standard human capital models. In the latter, working time and investment in OJT are rivalrous. In LBD-models they are not; current earnings raise future earnings as higher current earnings reflect more labor effort which implies that there is more learning-by-doing – for given rental rates per unit of human capital. See also Killingsworth (1982) and Heckman et al. (2002).

However, learning-by-doing theories resemble standard OJT-theories once a general perspective is adopted (Heckman et al. 2002). In a partial equilibrium setting, the acquisition of human capital appears as manna from heaven in LBD-theories. However, this is a problematic feature in general equilibrium. Jobs that feature a lot of LBD would have a larger present value of earnings than jobs without human capital accumulation through LBD. Equilibrium in the labor market would then require that jobs without LBD must have the same present value in earnings as jobs with LBD as long as competition drives the firms' profits to zero. Suppose that a job without LBD pays a flat rate spot wage rate, then the job with LBD must pay lower wages at the beginning of the lifecycle and higher wages at the end of the lifecycle for the present value of wages in the LBD-job to be equal to the job without LBD. Hence, the is LBD-model is observationally equivalent to the standard Ben-Porath model and under some conditions they may even be identical (Killingsworth, 1982; Heckman et al. 2002). Learning-by-doing models are therefore empirically hard to distinguish from standard human capital models. Indeed, both the time invested in OJT-investments and the time accumulating work experience are hard to measure. As such, there appears no clear way to discriminate between the two models.

## 6 Remaining gaps in knowledge: main challenges

### 6.1 Theory

We do not yet know what is the most appropriate theory that describes human capital formation and earnings over the lifecycle. This paper started from the classical Ben-Porath (1967) model of general OJT-investments, which is firmly grounded in neoclassical human capital theory. This is a useful benchmark, given that the empirical evidence is completely in line with the predictions of the theory. However, competing theories could provide alternative explanations for the patterns we see in the data. The learning-doing-theories are observationally equivalent from a general equilibrium perspective. Hence, it does not seem to matter much for practical purposes whether human capital is accumulated through training on-the-job or learning-by-doing. However, the theories on specific training and training in monopsonistic labor markets are

clearly not compatible with standard human capital models. However, both theories have some predictions that are more difficult to reconcile with the data. Incentive theories (as developed by Lazear) for sure describe some real-world features of earnings-profiles. Nevertheless, they do not say anything about human capital accumulation. Hence, for the time being, it seems most practical to start with standard human capital models – as developed in this paper.

The role of market failures and institutions are likely to be very important, but little is known. Although some work on this has been done in static or one-shot models of investment in OJT, the literature in the field shows a completely scattered picture of the impacts of different labor market settings and institutions on OJT or lifecycle earnings. A fundamental empirical problem is that most empirical analyses are confined to working individuals only. Hence, these samples suffer from attrition since they do not include non-working individuals that could have been priced out of the labor market. Consequently, the identification of the impact of various labor market imperfections and institutions could be seriously biased. Moreover, the role of capital markets, saving and pension policies for human capital investments is a seriously underresearched area.

### 6.2 Structural estimation

Even if one accepts the most simple human capital framework to analyze human capital investments over the lifecycle, one runs into a host of methodological and data problems. Indeed, the data are likely to remain a substantial bottleneck, because training in firms is hard to verify/measure by the analyst. Moreover, it appears even more difficult to separate specific from general training. Also the returns to OJT are difficult to quantify given the non-verifiability of investments (flows) and human capital levels (stocks). Developing structural models appears to be the most promising, and perhaps the only route for future research. By estimating structural models one can identify non-observables such as time invested in OJT (see e.g. Heckman et al. 1998; Heckman et al., 2002).

Also structural empirical models need to be firmly grounded in theory, however. The identification of non-observables is as good as the theoretical structure that is imposed on the data. In particular, the modeling of the market structure is key. Before any serious structural estimation can be done, it is therefore urgent to theoretically analyze labor market imperfections, capital markets and various institutional details in dynamic human capital models.

### 6.3 Quasi-experiments

Identification problems in estimating the impact of various market structures on OJT-investments are pervasive, since many of the impacts of labor market and institutional details may not be individual specific and only change slowly over time. Consequently, structural methods (to identify OJT-investment) should probably be combined with quasi-experimental evidence (for example, due to policy-changes) to estimate the impact of institutions, labor and capital markets for the lifecycle patters of earnings, OJT-investments, saving and retirement.

Also panel data should ideally be used to identify lifecycle interactions. Estimates based on cross-sectional data could be biased, since lifecycle patterns for individuals may not coincide with cross-sectional patterns. Moreover, panel data allow the econometrician to eliminate some

of non-observed individual heterogeneity. Finally, panel data are suitable to estimate the impact of quasi-experiments.

# 7 Current state of play of European research infrastructures and networks

Various research groups operate within their own disciplines. For example, a group of empirical micro-economists has done extensive theoretical and empirical work on training. See the authors mentioned in Bassanini et al. (2005). There are also numerous researchers working on retirement. See for prominent examples the ones participating in the project of Gruber and Wise (1999; 2002). Similarly, a number of researchers have extensively analyzed saving behavior, for example, in the research group of Richard Blundell at UCL/IFS. However, to our knowledge there is not a single research group in Europe analyzing the joint impacts of labor and capital markets and institutions on the incentives for on-the-job training, pension saving and retirement.

# 8 Required research infrastructures, methodological innovations, data, networks etc. and consequences for research policy

The requirements to fully understand interactions between human capital, retirement and pensions are demanding. The policy questions raised in the introduction can only be answered by an innovative combination of theory, structural econometrics, quasi-experimental evidence, more and better data and micro-panel data analysis. Despite the high policy relevance, the complexity of all this may easily become too large to obtain important results anytime soon.

Theorists should develop better lifecycle theories of human capital investment that address the role of labor market imperfections, capital markets and various institutional details. It also requires that empirical economists should start to use more structural models to identify non-observable investment in human capital. Empirical economists should also try to develop empirical strategies to test the relevance of competing theories under different labor market conditions. Data collection should take into account that labor market frictions may result in censored samples, since some workers are priced out of labor markets. These workers need to be included for any meaningful assessment of labor market distortions. Identifying the role of institutions requires quasi-experiments. Probably only micro-panel data appear to be useful in order to fully identify lifecycle interactions, to obtain unbiased lifecycle profiles and to make quasi-experimental evaluations.

Cross-fertilization between different sub-disciplines in labor theory and econometrics appears to be necessary. Moreover, insights from public finance are important to understand the institutional impacts on labor market outcomes, saving and retirement choices. In order to achieve this cooperation among research groups is vital.

# Appendix

## Model in discrete time

For simulation purposes we write the continuous-time model in discrete time. The utility function is given by

$$\sum_{t=0}^{T} \frac{U(C_t)}{(1+\rho)^t} + X(T-R), \quad U', X' > 0, \quad U'', X'' < 0. \tag{22}$$

The life-time household budget constraint is:

$$\sum_{t=0}^{T} \frac{C_t}{(1+r^*)^t} = \sum_{t=0}^{R} \frac{(1-\tau_L)W(1-I_t)H_t}{(1+r^*)^t} + \sum_{t=R}^{T} \frac{(1-\tau_P)P}{(1+r^*)^t}. \tag{23}$$

And the human capital accumulation equation is:

$$H_{t+1} - H_t = BF(I_t H_t) - \delta H_t, \quad 0 \leq t \leq R. \tag{24}$$

The Lagrangian for maximizing life-time utility is given by

$$\begin{aligned} \max_{\{C_t, R_t, I_t, H_t\}} \mathcal{L} \quad \equiv \quad & \sum_{t=0}^{T} \frac{U(C_t)}{(1+\rho)^t} + X(T-R) + \sum_{t=0}^{T} \mu_{t+1} \left[(1-\delta)H_t + BF(I_t H_t) - H_{t+1}\right] \\ & + \lambda_0 \left[\sum_{t=0}^{R} \frac{(1-\tau_L)W(1-I_t)H_t}{(1+r^*)^t} + \sum_{t=R}^{T} \frac{(1-\tau_P)P}{(1+r^*)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+r^*)^t}\right], \end{aligned} \tag{25}$$

The first-order conditions are denoted by

$$\frac{\partial \mathcal{L}}{\partial C_t} = \frac{U'(C_t)}{(1+\rho)^t} - \lambda_t = 0, \quad 0 \leq t \leq T, \tag{26}$$

$$\frac{\partial \mathcal{L}}{\partial R} = -X'(T-R) + \lambda_R \left((1-\tau_L)W(1-I_R)H_R - (1-\tau_P)P\right) \geq 0, \tag{27}$$

$$\frac{\partial \mathcal{L}}{\partial I_t} = \mu_{t+1} BF'(.)\, H_t - \lambda_t (1-\tau_L) W H_t = 0, \quad 0 \leq t \leq R, \tag{28}$$

$$\frac{\partial \mathcal{L}}{\partial H_t} = \mu_{t+1}\left[BF'(.)I_t + 1 - \delta\right] - \mu_t + \lambda_t (1-\tau_L) W (1-I_t) = 0, \quad 0 \leq t \leq R, \tag{29}$$

where $\lambda_t \equiv \lambda_0 (1+r^*)^{-t}$. And the transversality condition is

$$\mu_{R+1} = 0. \tag{30}$$

The Euler equation consumption is

$$\frac{U'(C_{t+1})}{U'(C_t)} = \frac{1+\rho}{1+r^*}. \tag{31}$$

In the simulations we employ a CRRA felicity function, $U(C_t) = \frac{C_t^{1-1/\theta}}{1-1/\theta}$, so that

$$\frac{C_{t+1}}{C_t} = \left(\frac{1+r^*}{1+\rho}\right)^{\theta}. \tag{32}$$

The retirement decision is governed by (note $I_R = 0$)

$$\frac{X'(T-R)}{\lambda_0(1+r^*)^{-R}} \geq (1-\tau_R)(1-\tau_L)WH_R. \tag{33}$$

If $U(C_t) = \frac{C_t^{1-1/\theta}}{1-1/\theta}$ and $X(T-R) = \gamma\frac{(T-R)^{1-1/\beta}}{1-1/\beta}$, we have

$$\frac{\gamma(T-R)^{-1/\beta}}{C_0^{-1/\theta}(1+r^*)^{-R}} \geq (1-\tau_R)(1-\tau_L)WH_R. \tag{34}$$

Investment in human capital follows from

$$m_{t+1}BF'(.) = (1+r^*)(1-\tau_L)W, \tag{35}$$

where $m_t \equiv \mu_t/\lambda_t$, and we used $\frac{m_{t+1}}{m_t} = \frac{\mu_{t+1}/\lambda_{t+1}}{\mu_t/\lambda_t}$, and $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+r^*}$ from $\lambda_t = \lambda_0(1+r^*)^{-t}$.

Rewrite the first-order condition for $H_t$ to find a first-order difference equation in $m_t$:

$$\left(\frac{1-\delta}{1+r^*}\right)m_{t+1} - m_t + (1-\tau_L)W = 0. \tag{36}$$

To solve this equation, define $x \equiv \frac{1-\delta}{1+r^*}$ and $b \equiv (1-\tau_L)W$ so as to find

$$m_t = xm_{t+1} + b. \tag{37}$$

Repeated substitution yields

$$m_{t+1} = m_0x^{-t-1} - b\sum_{v=0}^{t} x^{(v-t-1)}. \tag{38}$$

Using the transversality condition ($m_{R+1} = 0$) gives

$$m_0 = b\sum_{v=0}^{R} x^v. \tag{39}$$

Hence,

$$m_{t+1} = b\sum_{v=0}^{R-t-1} x^v. \tag{40}$$

Use $b \equiv (1-\tau_L)W$ and $x \equiv \frac{1-\delta}{1+r^*}$ to find

$$m_{t+1} = \frac{(1-\tau_L)W(1+r^*)}{r^*+\delta}\left(1 - \left(\frac{1+r^*}{1-\delta}\right)^{t-R}\right). \tag{41}$$

Conditional upon the initial level of consumption $C_0$ and retirement $R$, the Euler equation

for consumption pins down the whole time-path of consumption over the life-cycle. Similarly, for given $R$, the time-path of the marginal value of human capital $m_t$ is fully determined. Hence, we know the total path of investment, and the evolution of the human capital stock over the entire life-cycle. We thus end up with two non-linear equations (first-order condition for retirement and the household budget constraint) in two unknowns ($C_0$ and $R$). We numerically solve this system of equations.

### Uncompensated elasticity of retirement

Linearizing the first-order condition for retirement gives

$$-\frac{1}{\beta}\frac{d(T-R)}{(T-R)}+\frac{1}{\theta}\frac{dC_0}{C_0}=-\frac{d\tau_L}{(1-\tau_L)}. \tag{42}$$

Rewrite the first-order condition for consumption so as to obtain

$$C_t=\left(\frac{1+r^*}{1+\rho}\right)^{t\theta}C_0. \tag{43}$$

Substitute the last result in the household budget constraint – and using the definition for $\tau_R$ – to find

$$C_0\sum_{t=0}^{T}(1+r^*)^{t(\theta-1)}(1+\rho)^{-t\theta}=(1-\tau_L)\left(\sum_{t=0}^{R}\frac{W_t(1-I_t)H_t}{(1+r^*)^t}+\tau_R\sum_{t=R}^{T}\frac{W_RH_R}{(1+r^*)^t}\right). \tag{44}$$

At constant levels of investment in human capital $I_t$ (and therefore $H_t$), we have

$$\frac{dC_0}{C_0}=-\frac{d\tau_L}{1-\tau_L}. \tag{45}$$

We therefore obtain the following uncompensated elasticity of retirement $\varepsilon_R\equiv-\frac{dR}{R}\frac{(1-\tau_L)}{d\tau_L}$ with respect to the tax rate at constant investments in human capital

$$\varepsilon_R=\frac{(T-R)}{R}\beta\left(1-\frac{1}{\theta}\right). \tag{46}$$

As a consequence, $\theta>1$ is needed to get a positive uncompensated retirement elasticity. We require a value of $\beta=2$ if $\theta=1.25$ in order to obtain an uncompensated retirement elasticity of 0.2 if $R$ is calibrated at $R=40$ and the life-span $T=60$.

Note that if human capital responds adversely to a lower retirement age, the interaction with human capital raises the retirement elasticity. This would not affect the qualitative nature of the effects of a tax change, i.e. the condition that $\theta>1$ ($\theta<1$) is still necessary to obtain a positive (negative) uncompensated elasticity of retirement. It would only make the retirement choice more elastic.

## References


Acemoglu, Daron, and Jörn-Steffen Pischke (1998). "Why do Firms Train? Theory and Evidence", *Quarterly Journal of Economics*, 113, 79-119.

Acemoglu, Daron and Jörn-Steffen Pischke (1999). "The Structure of Wages and Investment in General Training", *Journal of Political Economy*, 107, 539-572.

Akerlof, George A., and Janet Yellen (1986). *Efficiency Wage Models of the Labor Market*, Cambridge: Cambridge University Press.

Attanasio, Orazio P., and Guglielmo Weber (1995), "Is Consumption Growth Consistent with Intertemporal Optimization?", *Journal of Political Economy*, 130, (6), 1121-1157.

Bassanini, Andrea, Alison L. Booth, Giorgio Brunello, Edwin Leuven, and Maria De Paola (2006). "Workplace Training in Europe" in: Giorgio Brunello, Pietro Garibaldi, and Etienne Wasmer (eds), *Education and Training in Europe*, Oxford: Oxford University Press, Chapters 8-13.

Becker, Gary S. (1964). *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*, Third edition 1993, Chicago: Chicago University Press.

Ben-Porath, Yoram (1967). "The Production of Human Capital and the Life Cycle of Earnings", *Journal of Political Economy*, 75, (4), 352-365.

Bernheim, B. Douglas (2002). "Taxation and Saving", in: Auerbach, Alan J., and Martin Feldstein (eds.), *Handbook of Public Economics*, Vol 3., Chapter 18, North-Holland: Elsevier.

Blau, Francine D. , Lawrence M. Kahn (1996). "International Differences in Male Wage Inequality: Institutions versus Market Forces", *Journal of Political Economy*, 104, (4), 791-837.

Booth, Alison L. (1995). *The Economics of the Trade Union*, Cambridge University Press, Cambridge.

Booth, Alison L., and Monojit Chatterji (1998). "Unions and Efficient Training", *Economic Journal*, 108, 328-343.

Bovenberg, A. Lans, and Frederick van der Ploeg (1994). "Effects of the Tax and Benefit System on Wage Formation and Unemployment", unpublished manuscript: University of Amsterdam/Tilburg.

Bovenberg, A. Lans (2006). "Tax Policy and Labor Market Performance", in: Jonas Agell and Peter B. Sørensen (eds.), *Tax Policy and Labor Market Performance*, Cambridge-MA: CESifo and MIT-Press.

Brunello, Georgio, and Simona Comi (2000). "Education and Earnings Growth: Evidence from 11 European Countries", IZA-Discussion Paper No. 140, Bonn: IZA.

Card, David (1999). "The Causal Effect of Education on Earnings", in: Orley Ashenfelter and David Card (eds.), *Handbook of Labor Economics – Vol 3A*, Amsterdam: Elsevier-North Holland, 1801-1863.

Carey, David, and Josette Rabesona (2004). "Tax Ratios on Labour and Capital Income and on Consumption", in: Peter Birch Sørensen (ed.), *Measuring the Tax Burden on Capital and Labor*, CESifo Seminar Series, Cambridge-MA: MIT Press.

Carneiro, Pedro and James J. Heckman (2003). "Human Capital Policy", in James J. Heckman and Alan B. Krueger (eds.), *Inequality in America: What Role for Human Capital Policy?*, Cambridge, MA: MIT Press.

Duval, Romain (2004). "Retirement Behavior in OECD Countries: Impact of Old-Age Pension Schemes and Other Social Transfer Programmes", *OECD Economic Studies*, 37, 2003/2, 7-50.

Freeman, Lawrence B., and Lawrence F. Katz (1995). "Introduction" and "Summary", in: Lawrence B. Freeman, and Lawrence F. Katz (eds.), *Differences and Changes in Wage Structures*, Chicago: University of Chicago Press.

Gottschalk, Peter and Timothy M. Smeeding (1997). "Cross-National Comparisons of Earnings and Income Inequality", *Journal of Economic Literature*, 35, (2), 633-687.

Gruber, Jonathan, and David Wise (1999). Social Security and Retirement around the World, Chicago: Chicago University Press.

Gruber, Jonathan, and David Wise (2002). "Social Security and Retirement around the World: Microestimation", NBER Working Paper No. 9407.

Hashimoto, M. (1981), "Firm-Specific Human Capital as a Shared Investment", *American Economic Review*, 71, (3), 475-482.

Heckman, James J. (1976). "A Life-Cycle Model of Earnings, Learning and Consumption", *Journal of Political Economy*, 84, S11-S44.

Heckman, James J. (2000). "Policies to Foster Human Capital", *Research in Economics* 54, (1), 3-56.

Heckman, James J., and Bas Jacobs (2007). "Policies to Create and Destroy Human Capital in Europe", paper prepared for: Hans-Werner Sinn and Edmund Phelps (eds.), *Perspectives on the Performance of the Continent's Economies*, CESifo and MIT-Press, forthcoming.

Heckman, James J., Lance Lochner, and Ricardo Cossa (2002). "Learning by Doing vs. On-the-Job Training: Using Variation Induced by the EITC to Distinguish between Models of Skill Formation", NBER Working Paper W9083.

Heckman, James J., Lance J. Lochner, and Christopher Taber (1998), "Explaining Rising Wage Inequality: Explorations with a Dynamic General Equilibrium Model of Labor Earnings with Heterogeneous Agents", *Review of Economic Dynamics*, 1, 1-58.

Heckman, James J., and Carmen Pagés (2003), "Law and Unemployment: Lessons from Latin America and the Carribbean", NBER Working Paper 10129, Cambridge MA: NBER.

Jacobs, Bas (2008), "Is Prescott Right? Welfare State Policies and the Incentives to Work, Learn and Retire", *International Tax and Public Finance*, forthcoming.

Killingsworth, Mark R. (1982), ""Learning by Doing" and "Investment in Training": A Synthesis of Two Models of the Life-Cycle", *Review of Economic Studies*, 49, (2), 263-271.

Layard, Richard, Stephen Nickell and, Richard Jackman (1991). *Unemployment*, Oxford: Oxford University Press.

Lazear, Edward P. (1976). "Age, Experience, and Wage Growth", *American Economic Review*, 66, (4), 548-558.

Lazear, Edward P. (1979). "Why Is There Mandatory Retirement?", *Journal of Political Economy*, 87, (6), 1261-1284.

Leazear, Edward P. (1981). "Agency, Earnings Profiles, Productivity, and Hours Restrictions", *American Economic Review*, 71, (4), 606-620.

Leuven, Edwin (2005). "The Economics of Private-Sector Training: A Review of the Literature", *Journal of Economic Surveys*, 19, (1), 91-111.

Leuven, Edwin, and Hessel Oosterbeek (2001). "Firm-Specific Human Capital as a Shared Investment: Comment", *American Economic Review*, 91, (1), 342-347.

Lindbeck, Assar, and Dennis J. Snower (1988). *The Insider-Outsider Theory of Employment and Unemployment*, Cambridge-MA: MIT Press.

Lindbeck, Assar, and Dennis J. Snower (2002). "The Insider-Outsider Theory: A Survey", IZA Discussion Paper No. 534, Bonn: IZA.

Lucas, Robert E. Jr. (1990). "Supply-Side Economics: An Analytical Review", *Oxford Economic Papers*, 42, 293-316.

Manning, Allan (2003), *Monopsony in Motion: Imperfect Competition in Labor Markets*, Princeton University Press: New Jersey.

Mincer, Jacob (1958). "Investment in Human Capital and Personal Income Distribution", *Journal of Political Economy*, 66, 281-302.

Mincer, Jacob (1962). "On the Job Training: Costs, Returns and Some Implications", *Journal of Political Economy*, 70, 50-79.

Mincer, Jacob (1974), Schooling, Experience, and Earnings, Cambridge MA: NBER, distributed by Columbia University Press, New York.

Mortensen, Dale T., and Christopher A. Pissarides (1999). "New Developments in Models of Search in the Labor Market", in: Orley Ashenfelter and David Card (eds.), *Handbook of Labor Economics – Vol 3B*, Amsterdam: Elsevier-North Holland, 2567-2627.

Nickell, Stephen (1997). "Unemployment and Labor Market Rigidities: Europe versus North America", *Journal of Economic Perspectives*, 11, (3), 55-74.

OECD (2004). The Labor Force Participation of Older Workers: The Effects of Pension and Early Retirement Schemes, Working Paper, OECD Economics Department, May 2004.

OECD (2005), *Pensions at a Glance*, Paris: OECD.

OECD (2006), *OECD Labor Force Statistics Database*, Paris: OECD.

OECD (2007), *OECD Tax Database*, Paris: OECD.

Ploeg, Frederick van der (2006). "Do Social Policies Harm Employment? Second-Best Effects of Taxes and Benefits on Labor Markets", in: Jonas Agell and Peter B. Sørensen (eds.), *Tax Policy and Labor Market Performance*, Cambridge-MA: CESifo and MIT-Press.

Schultz, Theodore W. (1963). *The Economic Value of Education*, New York: Columbia University Press.

Skirrbekk, Vegard (2005), "Age and Productivity: A Literature Survey", mimeo: International Institute for Applied Systems Analysis.

Sørensen, Peter B. (1999). "Optimal Tax Progressivity in Imperfect Labour Markets", *Labour Economics*, 6, (3), 435-452.

Teulings, Coen N. (2003). "The Contribution of Minimum Wages to Increasing Wage Inequality", *Economic Journal*, 113, (490), 801-833.

Trostel, Philip A. (1993) "The Effect of Taxation on Human Capital", *Journal of Political Economy*, 101, (2), 327-350.

Weiss, Yoram (1986). "The Theory of Life-Cycle Earnings", in: Ashenfelter, Orley, and Richard Layard (eds.), *Handbook of Labor Economics – Vol 1*, Amsterdam: Elsevier-North Holland.

# Age-specific dynamic human capital investment. The role of labor supply and demand

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**Abstract**

We introduce a normative model of the optimal education policy at the macro level allowing for heterogeneity of the workforce with respect to its age and qualification skills. Within this framework we study the optimal education rate in the context of changes in the labor demand (as represented by the elasticity of substitution across ages and qualification) and labor supply (as represented by a change in the population growth rates). Applying an age-structured optimal-control model we derive features of the optimal education rate. Our results show that the relation between the elasticities of substitution of labor across ages plays a crucial role for the way the demographic changes affect (both in the short and in the long run) the optimal educational policy. We also show that under imperfect substitutability across age and qualification groups the optimal educational policy is adjusted in advance to any change in the labor supply.

*Key words:* human capital, age-composition of labor, age-structured model, optimal control
*JEL:* C61, J23, J24

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# 1 Introduction

Changes in the age distribution of the workforce - as caused by changes in the cohort size of entering labor flows - and its implications for labor market outcomes such as wages and unemployment have been extensively discussed in the empirical economic literature (Freeman 1979; Katz and Murphy 1992; Murphy and Welch 1992; Welch 1979). Besides the age structure, the skill level constitutes a further important heterogeneity of workers in the labor market. Labor market outcomes for different skill groups (in particular wage dispersion) are extensively studied (e.g. Katz and Autor 1999).

In a seminal paper (Card and Lemieux 2001) the authors reconcile the work of Welch (Welch 1979) and Katz and Autor (Katz and Autor 1999). Card and Lemieux introduce an aggregate production function that accounts for imperfect substitutability of workers across age and education. Their aim is to explain the empirical fact that the rise in education related wage differentials in the US from 1959-1995 is mainly due to a rise in the college-high school wage gap for younger men while the gap for older men has remained fairly constant over the same time period (1959-1995). Within their framework the authors show "that the increase in the college-high school wage gap over the past two decades is attributable to steadily rising relative demand for college-educated labor, coupled with a dramatic slowdown in the rate of growth of the relative supply of college-educated workers".

As argued in (Rojas 2005), the implications of these empirical studies have not yet been integrated into formal macroeconomic models except in (Lam 1989) and in (Kremer and Thomson 1998). While Lam considered the change in age structure on life-cycle wage profiles in a stable population, Kremer and Thomson study the role of imperfect substitution across workers of different age to explain the speed of convergence of per capita output between countries.

The assumption that workers of different ages are not perfectly substitutable across age and education however implies that there is an optimal age-education mix of the workforce (in terms of output maximization). Our aim is to provide a normative model of the optimal education/training policy at the macro level allowing for heterogeneity of the workforce with respect to its age and qualification skills. Within this framework we study the optimal education/training rate in the context of alternative labor demand and labor supply effects. The degree of substitutability across workers of different age and education characterizes the labor demand pattern. Labor supply is determined by the inflow of low and high skilled workers. Since we assume zero mortality and full employment labor supply is determined by a change in the demographic factors in our model.

Our paper is motivated by the fact that population ageing implies a change in the age and educational composition of the workforce and, hence, requires a change in the optimal age-specific human capital investment. Obviously the substitutability of workers across age and across qualifications, together with increasing demand for educated workers and technological

progress, constitute key factors explaining the relation between demographic change and educational investment.

According to the theory of optimal life cycle human capital investment, human capital accumulation concentrates at the beginning of life (Weiss 1986). An economy characterized by population ageing might therefore exhibit an 'older vintage' of human capital. It is therefore of interest how a social planner will react in terms of its age-specific human capital investment under conditions of labor force ageing and faced with alternative labor demand patterns.

In summary, our paper is intended to raise and to address the following questions:

(i) Compared to the case of perfectly substitutable labor across ages and across education, how will the optimal age-specific educational policy change under conditions of imperfectly substitutable labor across age and across qualification groups.
(ii) Compared to the case of a stationary population, how will an increasing or decreasing population (hence change in the labor supply) affect the optimal educational policy.
(iii) Will the long-run and short-run effects of a change in the demand and supply factors of labor differ? In particular, will a change in demographic factors be anticipated in the optimal educational policy in advance of the time point where the actual change takes place?

We start from a model of aggregate production with age and skill specific supplies of labor. We assume that aggregate output depends on two constant elasticity of substitution (CES) aggregates of low and high skilled employees which are in turn combined in a production function of the CES type. We take imperfect substitutability between human capital of different age groups as given and explore how it affects the dynamic optimal path of human capital investment. We only model a public education system where the government determines the level of education.[1]

As we will show, the relation between the substitutability of workers across ages in the low-skilled versus high-skilled aggregate will determine whether population ageing increases or decreases human capital accumulation. Put differently, changes in age group specific supplies of workers together with the prevailing demand structure of the economy—as reflected by the parameters of the elasticity of substitution—will determine whether human capital increases or decreases. Moreover, whether human capital decisions are already taken in advance of a demographic change or not will depend on the substitutability of workers across age and educational groups.

While the age structure has been introduced into the neoclassical theory of optimal investment in several recent contributions (e.g. Barucci and Gozzi 2001; Feichtinger et al. 2005),

[1]Positive external effects of education justify its public provision.

we are only aware of the paper (Christiaans 2003) and our own work (Prskawetz and Veliov 2007) that augmented the classical theory of labor demand by modelling the age structure of the workers. The vintage structure of human capital has been integrated into a model of endogenous growth by (Boucekkine et al. 2001). To solve the continuous-time dynamic optimization model we apply the maximum principle for systems with distributed parameters developed in (Feichtinger et al. 2003).

The structure of the paper is as follows. In the next section we present the theoretical framework of our study. As a modelling tool we employ a continuous-time-continuous-age vintage model in the form of a first order partial differential equation. Optimality conditions are presented in Section 3. Section 4 is devoted to the case of perfect substitutability of labor across ages and across educational groups. For this case it can be shown that the optimal age-specific education rate is independent of the initial age structure of low- and high- skilled workers and the inflow of those skill groups over time. In other words, given perfect substitutability of workers across age and qualification, the optimal educational rate will be independent of a demographic change. Furthermore we show that the optimal educational rate might be non-monotonic in age. In Section 5 we extend our framework to allow for imperfect substitutability of workers across age within skill groups but keep the assumption of perfect substitution across skill groups. We study the long run effects of a demographic change—as represented by an increasing or decreasing inflow of workers as opposed to a constant inflow—on the optimal age-specific learning rate. As a first result we establish that the optimal educational policy for an exponentially changing population is exactly the same as for a stationary population with modified data of the age-specific productivities of both skill groups as well as the price and discount rate. We then numerically verify that for an exponentially increasing (decreasing) population the optimal age-specific educational rate shifts to older (younger ) ages in case the substitutability across ages is lower for high-skilled workers as compared to low-skilled workers. If the substitutability of workers across ages within educational groups is reverse the results reverse as well. For the case of perfect substitutablity across workers of different ages in the high-skilled group and imperfect substitutablity of workers of different ages in the low-skilled group we provide a proof of the numerically obtained results. The obvious message from these results is the fact, that a change in the optimal age-specific educational rate as a consequence of a demographic change will depend on the demand pattern of the labor market as represented by the coefficients of the elasticity of substitution in the low- and high- skilled labor aggregates in combination with the supply factors as represented by the assumption of an increasing, decreasing or constant population. In Section 6 we study the short run effects of a change in the labor supply. A key finding is that in case of imperfect substitutability of labor (either across ages or across qualifications) a change in the labor supply influences the optimal education policy already in advance of the time point when the change takes place. Such an anticipation effect has been found in related studies (e.g. in Prskawetz and Veliov 2007). We furthermore present numerical and analytical results for the optimal age specific education rate for three population scenarios. The analysis clearly exhibits the importance of the relation between the elasticities of substitution across ages of skilled and unskilled labor, which may lead to

different (opposite) impacts of the demographic change on the optimal educational policy. In Section 7 we study the path of the wage differential between high and low skilled workers over time under the assumption that workers of higher skill are less substitutable across ages compared to lower skilled workers and for different scenarios of the population growth rates. We show that the evolution of the wage differential among younger workers in relation to the change in the mean age of the population is consistent with the empirical findings of Card and Lemieux. The final section concludes the paper. The benchmark data specification are given in Appendix 1. Some more technical proofs are collected in Appendix 2.

# 2 The model

Below $t \in [0, T]$ denotes the time, $T$ is the end of the (presumably large) planning horizon. In our model the workers will be distinguished by their "active" age, $s$. It is assumed that all individuals start working at the same age $s = 0$ (which corresponds to, say, 20 years of biological age) and retire at age $s = \omega$. Following (Card and Lemieux 2001) we distinguish the workers also by their skills, considering for simplicity two levels of qualification: low-skilled and high-skilled workers. We denote by $L(t, s)$ the amount of low-skilled workers of age $s$ at time $t$, and similarly, by $H(t, s)$ – the amount of high-skilled workers resulting from the government's investment in human capital.

Upgrading of low-skilled workers into high-skilled workers takes place with a rate $l(t, s)u(t, s) + e(s)$. Here $u(t, s)$ denotes the educational rate at time $t$ for workers of age $s$. The function $l(t, s)$ reflects the dependence of the learning abilities of the workers on time and age, and $e(s)$ represents the learning by doing which depends on the years spent working. At the same time, due to the technological progress or other reasons, high-skilled workers of age $s$ may lose their skills with a rate $\delta(t, s)$.

The dependence of the learning abilities on age is investigated in (Pfeiffer and Reuß 2007). As the authors demonstrate, though older persons might already have high levels of skills as opposed to younger persons, their learning ability is slower as compared to a younger person. They also show that skill depreciation accelerates with age. Besides the age-specific dependence of learning and depreciation, learning abilities may also depend on time due to the technological progress.

The equations for the dynamics of the stock of low- and high-skilled workers are therefore

$$\begin{aligned} L_t + L_s &= \delta(t,s)H(t,s) - e(s)L(t,s) - l(t,s)u(t,s)L(t,s), \qquad L(t,0) = L_0(t), \\ H_t + H_s &= -\delta(t,s)H(t,s) + e(s)L(t,s) + l(t,s)u(t,s)L(t,s), \qquad H(t,0) = H_0(t), \\ & L(0,s),\ H(0,s) \text{ – given initial data.} \end{aligned}$$

The left hand side, $L_t + L_s = \lim_{h\to 0}(L(t + h, s + h) - L(t, s))/h$, represents the change in one unit of time of the low-skilled labor that is of age $s$ at time $t$. This change is composed of

downgrading high-skilled to low-skilled workers (decay of human capital) at the rate $\delta(t,s)$ and of upgrading low-skilled to high-skilled workers at the rate $e(s)$ due to costless on the job learning by doing and at the rate $l(t,s)u(t,s)$ due to costly education. Similarly, the left hand side, $H_t + H_s$ represents the change in one unit of time of the high-skilled labor. This change is composed of the same components as the change of the low-skilled labor, but with the opposite sign.

At age $s = 0$ the number of those who enter the work force at time $t$ is $L_0(t)$ for the low-skilled and $H_0(t)$ for the high-skilled. We assume throughout the paper that $H_0(t)$ is for each $t$ relatively small compared with $L_0(t)$. This reflects the fact that all but a few high school graduates enter the work force as low-skilled workers and have to undergo additional education/training in order to become high-skilled.

We assume also that there is no unemployment and there is no mortality at working ages, therefore the sum $L(t,s) + H(t,s)$ equals the total population, which is determined by the exogenously given total inflow, $N_0(t)$. Thus $L_0(t) + H_0(t) = N_0(t)$. This allows to exclude the variable $H(t,s)$ from the model and to pass to a single differential equation for $L(t,s)$. However, for the purposes of better transparency of the exposition we shall work with both equations for $L(\cdot,\cdot)$ and $H(\cdot,\cdot)$.

The price of the per capita education $u(t,s)$ is $p(s,u(t,s))$, where $p(\cdot,\cdot)$ is a given function of $(s,u)$. The total cost $P(t)$ of the educational effort for the society at time $t$ is therefore represented as

$$P(t) = \int_0^\omega p(s,u(t,s))L(t,s)\,\mathrm{d}s.$$

We allow for imperfect substitutability across age groups for both low-skilled and high-skilled labour. If $\pi_L(\cdot)$ and $\pi_H(\cdot)$ are the respective relative efficiency parameters (assumed to be fixed over time), the two sub-aggregates of low-skilled and high-skilled labour at time $t$, $\tilde{L}(t)$ and $\tilde{H}(t)$, are given by the following two CES functions

$$\tilde{L}(t) = \left(\int_0^\omega \pi_L(s)(L(t,s))^{\lambda_L}\,\mathrm{d}s\right)^{1/\lambda_L}, \qquad \tilde{H}(t) = \left(\int_0^\omega \pi_H(s)(H(t,s))^{\lambda_H}\,\mathrm{d}s\right)^{1/\lambda_H}.$$

Here $\lambda_L \in (-\infty, 1]$ and $\lambda_H \in (-\infty, 1]$ give the respective partial elasticity of substitution $\frac{1}{1-\lambda_i}$ for $i = L, H$. In the limiting case of perfect substitutability across age groups $\lambda_L$ and $\lambda_H$ are equal to 1 and the aggregate of low-skilled and skilled-labor is simply a weighted sum of age-specific supply.

We assume that the production technology depends only upon labor. The aggregate output at time $t$ is given by a CES function of the two sub-aggregates of low-skilled and high-skilled

labor, in which the technological level is represented by the two efficiency parameters $\theta_L(t)$ and $\theta_H(t)$:

$$Y(t) = \left(\theta_L(t)(\tilde{L}(t))^\rho + \theta_H(t)(\tilde{H}(t))^\rho\right)^{1/\rho}.$$

Here again $\rho \in (-\infty, 1]$ gives the partial elasticity of substitution $\sigma_W = \frac{1}{1-\rho}$ between high-skilled and low-skilled labor. Note that in (Card and Lemieux 2001) the marginal product of labor for a given age-education group depends on the group's own supply of labor and the aggregate supply of labor in the education category.

The net revenue of the society at time $t$ is the aggregate output $Y(t)$ minus the cost of education, $P(t)$, i.e. $Y(t) - P(t)$.

The formal problem of a central planner is to maximize the accumulated discounted net revenue by choosing optimally the educational rate $u(t,s)$. Discounting the future with a rate $r \geq 0$ we come up with the following dynamic optimization problem with state variables $L(t,s)$, $H(t,s)$, $\tilde{L}(t)$, $\tilde{H}(t)$ and $P(t)$, and control variable $u(t,s)$:

$$\max \int_0^T e^{-rt}\left[\left(\theta_L(t)(\tilde{L}(t))^\rho + \theta_H(t)(\tilde{H}(t))^\rho\right)^{1/\rho} - P(t)\right] \mathrm{d}t \tag{1}$$

subject to

$$\begin{aligned}
L_t + L_s &= \delta(t,s)H(t,s) - e(s)L(t,s) - l(t,s)u(t,s)L(t,s), \qquad L(t,0) = L_0(t), && (2)\\
H_t + H_s &= -\delta(t,s)H(t,s) + e(s)L(t,s) + l(t,s)u(t,s)L(t,s), \qquad H(t,0) = H_0(t), && (3)\\
&\quad L(0,s),\ H(0,s) \text{ – given initial data,} \\
\tilde{L}(t) &= \left(\int_0^\omega \pi_L(s)(L(t,s))^{\lambda_L}\,\mathrm{d}s\right)^{1/\lambda_L}, && (4)\\
\tilde{H}(t) &= \left(\int_0^\omega \pi_H(s)(H(t,s))^{\lambda_H}\,\mathrm{d}s\right)^{1/\lambda_H}, && (5)\\
P(t) &= \int_0^\omega p(s,u(t,s))L(t,s)\,\mathrm{d}s, && (6)\\
&\quad u(t,s) \geq 0. && (7)
\end{aligned}$$

Since our model does not include the education as a separate sector (cf. Lucas, 1988; Boucekkine and Ruiz-Tamarit, 2004), the control $u$ is directly interpreted as on-the-job training. However, the results are not limited to this interpretation. Indeed, let the workers of different qualification be perfectly substitutable ($\rho = 1$) and let the unskilled workers of different ages also be perfectly substitutable ($\lambda_L = 1$). Then an amount of labor, $uL$, of age $s$ allocated at time $t$ to education instead of production has a total cost consisting of the opportunity cost $\pi_L(s)\theta_L uL$ (from lost production) and the cost of education. Both costs may

be included in $p(s,u)L$, therefore our model completely covers the case of college/university education in the case of linear production function. In the general case one cannot represent the opportunity cost of education by the cost function $p(s,u)L$ but a function $p$ defined as above using the linearization of $Y$ along a reference trajectory can be used as a proxi for the cost of the off-the-job education. Therefore we can view our education as training, as study, or as including both.

The next assumptions will be supposed to hold throughout the paper.

*Standing Assumptions:* All exogenous functions are continuous as well as the derivatives that appear later on in the text, excluding the population inflow data $L_0(t)$ and $H_0(t)$, which are assumed only piecewise continuous. The cost function $p(s,u)$ is monotonely increasing and strongly convex with respect to $u$. The initial and the boundary data $L(0,s)$, $H(0,s)$, $L_0(t)$ and $H_0(t)$, as well as the efficiency coefficients $\theta_L$, $\theta_H$, $\pi_L$ and $\pi_H$ are strictly positive.

The strong convexity assumption for $p(s,\cdot)$ provides a substantial mathematical convenience, as usual. At the same time it can be economically justified: the bigger the fraction of the low-skilled workers of a certain age which are involved in education, the larger the per capita educational cost due to the heterogeneity of people with respect to their abilities (the best are taken first in the educational process).

For a precise definition of the notion of a solution to system (2)–(6) and the appropriate space settings we refer to (Webb 1985) and to (Feichtinger et al. 2003).

# 3 Optimality conditions

To obtain necessary optimality conditions for problem (1)–(7) we apply the Pontryagin type maximum principle obtained in (Feichtinger et al. 2003) [2]. We introduce the following *adjoint system* for the problem (1)–(7):

$$\begin{aligned}\xi_t + \xi_s &= r\xi + (\xi-\eta)(e(s)+l(t,s)u(t,s)) - \\ &\quad (Y(t))^{1-\rho}\theta_{_L}(t)\pi_{_L}(s)(\tilde{L}(t))^{\rho-\lambda_L}(L(t,s))^{\lambda_L-1} + p(s,u(t,s)), \qquad (8)\\ &\quad \xi(t,\omega)=0, \quad \xi(T,s)=0,\\ \eta_t + \eta_s &= r\eta + (-\xi+\eta)\delta(t,s) - \\ &\quad (Y(t))^{1-\rho}\theta_{_H}(t)\pi_{_H}(s)(\tilde{H}(t))^{\rho-\lambda_H}(H(t,s))^{\lambda_H-1}, \qquad (9)\\ &\quad \eta(t,\omega)=0, \quad \eta(T,s)=0,\end{aligned}$$

[2] In order to apply the result from (Feichtinger et al. 2003) the problem (1)–(7) has to be first rewritten in terms of the variables $\bar{L}=\tilde{L}^{\lambda_L}$ and $\bar{H}=\tilde{H}^{\lambda_H}$. Moreover in the present context it is more convenient to work with the current value adjoint variables, which are obtained from the adjoint variables in (Feichtinger et al. 2003) by multiplication with $e^{rt}$. Here we omit these technicalities. We mention that the earlier general optimality condition obtained in (Brokate 1985) is not applicable here due to the dependence of the integral relation (6) on the control $u$.

where $\xi(\cdot,\cdot)$ and $\eta(\cdot,\cdot)$ are the adjoint variables corresponding to the state equations (2) and (3), respectively. Theorem 1 in (Feichtinger et al. 2003) claims that if $(L, H, \tilde{L}, \tilde{H}, P, u)$ is a solution to the optimal control problem (1)–(7) then a unique solution $\xi(\cdot,\cdot), \eta(\cdot,\cdot)$ of the adjoint system (8)–(9) exists, and for (almost) every $(t,s) \in [0,T] \times [0,\omega]$ the optimal $u(t,s)$ maximizes the function

$$(-\xi(t,s) + \eta(t,s))l(t,s)L(t,s)u - p(s,u)L(t,s)$$

over all $u \geq 0$.

Since it follows from (2) that $L(t,s)$ is always positive, $u(t,s)$ has to maximize

$$(-\xi(t,s) + \eta(t,s))l(t,s)u - p(s,u) \tag{10}$$

under the constraint $u \geq 0$. According to the standing assumptions the derivative $p_u(s,u)$ exists and is invertible with respect to $u$. Denote by $z \longrightarrow p_u^{-1}(s,z)$ the inverse and define

$$p_{u+}^{-1}(s,z) = \begin{cases} p_u^{-1}(s,z) & \text{if} \quad z > p_u(s,0), \\ 0 & \text{elsewhere.} \end{cases}$$

Then the unique maximizer of (10) subject to $u \geq 0$ can be written as

$$u(t,s) = p_{u+}^{-1}(s, l(t,s)\Delta(t,s)), \tag{11}$$

where $\Delta(t,s) = \eta(t,s) - \xi(t,s)$.

Notice that if $\Delta(t,s) > p_u(s,0)$ for some $(t,s)$ then $u(t,s) > 0$ and (11) reads as $p_u(s,u(t,s)) - l(t,s)\Delta(t,s) = 0$. Otherwise $u(t,s) = 0$. For example, with the usual specification $p(s,u) = b(s)u + 0.5cu^2$ the optimal control takes the form

$$u(t,s) = \begin{cases} (\eta(t,s) - \xi(t,s) - b(s))/c & \text{if} \quad \eta(t,s) - \xi(t,s) > b(s), \\ 0 & \text{elsewhere.} \end{cases} \tag{12}$$

Thus educational effort is applied only for those ages for which the marginal cost of education at $u = 0$ is exceeded by the benefit of the education, measured by the difference between the shadow prices of skilled and unskilled labor.

Subtracting the first adjoint equation from the second one and substituting $u$ from (11) we obtain that

$$\Delta_t + \Delta_s = (r + e(s) + \delta(t,s) + l(t,s)p_{u+}^{-1}(s, l(t,s)\Delta))\Delta - p(s, p_{u+}^{-1}(s, l(t,s)\Delta)) - f(t,s), \tag{13}$$

$$\Delta(t,\omega) = 0, \quad \Delta(T,s) = 0,$$

where

$$f(t,s) = (Y(t))^{1-\rho}\theta_{_H}(t)\pi_{_H}(s)(\tilde{H}(t))^{\rho-\lambda_H}(H(t,s))^{\lambda_H-1} - (Y(t))^{1-\rho}\theta_{_L}(t)\pi_{_L}(s)(\tilde{L}(t))^{\rho-\lambda_L}(L(t,s))^{\lambda_L-1}$$

is the age-specific differential of marginal productivities between high-skilled and low-skilled labor. It is important to notice that the function $p_{u+}^{-1}(s,\cdot)$ is Lipschitz continuous, therefore the above equation, together with the side conditions $\Delta(t,\omega) = 0$ and $\Delta(T,s) = 0$, uniquely determines the solution $\Delta(t,s)$, hence also the optimal control $u$ by (11).

# 4 The case of perfect substitutability of labor

In this section we consider the simplest case, in which problem (1)–(7) becomes linear with respect to the state variables[3]: the case of perfectly substitutable labor across ages and across qualifications, $\rho = \lambda_L = \lambda_H = 1$.

**Proposition 1** *The optimal educational rate $u(t,s)$ is independent of the initial data $L(0,s)$, $H(0,s)$, and of the low- and high-skilled workers inflows $L_0(t)$ and $H_0(t)$. If all data are time-invariant (except for $L_0(t)$ and $H_0(t)$) then $u(t,s) = u(s)$ is also time-invariant in the time-interval $[0, T-\omega]$.*

The proposition implies, in particular, that a demographic change (represented by $L_0(t)$ and $H_0(t)$)[4] would not have any influence on the optimal educational rate. Moreover, in the stationary case the end of the time-horizon $T$ may influence the optimal control no longer than one generation time before the end of the horizon, that is, on $[T-\omega, T]$ only.

**Proof.** To prove the first claim of the proposition we note that now $f(t,s) = \theta_H(t)\pi_H(s) - \theta_L(t)\pi_L(s)$ in (13) and the right-hand side of (13) and the side conditions do not depend on $L$ and $H$, therefore on the data $L(0,s)$, $H(0,s)$, $L_0(t)$ and $H_0(t)$. Since $\Delta$ does not depend on the demographic data, so does $u$ because of (11).

In the time invariant case we have $f(t,s) = f(s)$. Let us denote $z(\tau;a) = \Delta(\tau-a, \omega-a)$, where $\tau \in [0,T]$ is a parameter and $a \in [0, \min\{\tau,\omega\}]$. Then, denoting $a' = \omega - a$, we have

$$-\frac{\mathrm{d}}{\mathrm{d}a}z = (r + \delta(a') + e(a') + l(a')p_{u+}^{-1}(a', l(a')z))z - f(a') - p(a', p_{u+}^{-1}(a', l(a')z)).$$

[3]We stress that the problem is still nonlinear due to the bilinear dependence on $(L,u)$.

[4]We can denote a change in the initial level of low-skilled and high-skilled labor a demographic change since we abstract from an endogenous modelling of the labor market and assume full employment.

Clearly, the right-hand side is independent of $\tau$, and since we have $z(\tau,0)=\Delta(\tau,\omega)=0$, the solution $z(\tau;a)=z(a)$ is independent of $\tau$. For $t\in[0,T-\omega]$ and $s\in[0,\omega]$ we have

$$\Delta(t,s)=z(t+\omega-s;\omega-s)=z(\omega-s),$$

and the right-hand side is independent of $t$ (since $t+\omega-s\in[0,T]$ if $t\in[0,T-\omega]$). Using (11) we complete the proof. Q.E.D.

Several papers on optimal education and human capital formation ((Boucekkine et al. 2002; Weiss 1986) for a review of the theoretical literature on optimal life-cycle human capital investment) assume or conclude that the educational efforts are optimally allocated in youngest ages and decrease with age. We established numerically that this is not always true in our model, namely, the optimal educational rate, $u(s)$, may strictly increase at certain ages. Below we analyze mathematically the reason for this effect and give some economic explanations. To make the analysis more transparent we present it in the case of time-invariant data and a quadratic cost function $p(u)$. Moreover, it is clear that a decreasing learning ability $l(s)$ encourages learning in young ages and cannot be a reason for increasing learning with age. Therefore we assume the learning ability to be constant.

**Proposition 2** *Assume that all data (except for $L_0(t)$ and $H_0(t)$) are time-invariant and continuous in $s$, $l(s)=l$, $p(u)=bu+\frac{c}{2}u^2$. Let there exist some $s$ for which $u(s)>0$ and such that one of the following conditions holds:*

$$\text{(i)}\quad d(s)-\tfrac{b}{c}l\geq 0 \quad \& \quad \theta_H\pi_H(s)-\theta_L\pi_L(s)<\frac{b^2}{2c};$$

or

$$\text{(ii)}\quad d(s)-\tfrac{b}{c}l<0 \quad \& \quad \theta_H\pi_H(s)-\theta_L\pi_L(s)<\frac{b}{l}d(s)-\frac{c}{2l^2}(d(s))^2,$$

*where $d(s)=r+\delta(s)+e(s)$. Then there exists $s_0\in(0,\omega)$ where $u$ is differentiable and $u'(s_0)>0$.*

**Proof.** According to (12), in the time-invariant case

$$u(s)=\max\{0,\ \frac{1}{c}(l\Delta(s)-b)\},\tag{14}$$

$$\Delta'(s)=\left(r+\delta(s)+e(s)+lu(s)\right)\Delta(s)-f(s)-\left(bu(s)+\frac{c}{2}(u(s))^2\right),\tag{15}$$

where as before $f(s)=\theta_H\pi_H(s)-\theta_L\pi_L(s)$. Hence, the optimal control is a continuous function. Let $a$ be the minimal number such that $u(s)=0$ on $(a,\omega]$. Since $u$ is not identically zero, we have $a>0$. Clearly $u(s)>0$ on some maximal (to the left) interval $(a_0,a)$. Then

$$u(s)=\frac{1}{c}(l\Delta(s)-b)\quad \text{for } s\in(a_0,a),$$

In particular, $u$ is differentiable on $(a_0, a)$.

Assume that $u'(s) \leq 0$ on $(a_0, a)$. Apparently this implies $a_0 = 0$. Moreover, $\Delta(s)$ must satisfy $\Delta'(s) \leq 0$ on $(0, a)$. On this interval $\Delta$ satisfies the equation (resulting from (15) after substitution of $u(s)$ from (14))

$$\Delta'(s) = \left(r + \delta(s) + e(s) + \frac{l}{c}(l\Delta(s) - b)\right)\Delta(s) - \tag{16}$$
$$f(s) - \frac{b}{c}(l\Delta(s) - b) - \frac{1}{2c}(l\Delta(s) - b)^2.$$

Rearranging the terms we obtain

$$\Delta'(s) = q_2(\Delta(s))^2 + q_1\Delta(s) - q_0,$$

where

$$q_2 = \frac{l^2}{2c}, \quad q_1(s) = r + \delta(s) + e(s) - \frac{bl}{c}, \quad q_0 = f(s) - \frac{b^2}{2c}. \tag{17}$$

Since $\Delta'(s) \leq 0$, then for every $s \in (0, a)$ the quadratic form $q_2x^2 + q_1(s)x - q_0(s)$ takes a non-positive value for some $x \geq 0$. This means that

$$\min_{x \geq 0}\{q_2x^2 + q_1(s)x - q_0(s)\} \leq 0.$$

Calculating this minimum we obtain two possibilities.
Case (i): If $-\frac{q_1(s)}{2q_2} \leq 0$ then $q_0(s) \geq 0$,
Case (ii): If $-\frac{q_1(s)}{2q_2} > 0$ then $(q_1(s))^2 + 4q_0(s)q_2 \geq 0$.
Substituting from (17) one obtains that Case (i) contradicts assumption (i) and Case (ii) contradicts the alternative assumption (ii) of the proposition. This completes the proof. Q.E.D.

The sufficient conditions for non-monotonic behaviour of the optimal educational rate are fulfilled if
(i) $d(s) = r + \delta(s) + e(s)$ is sufficiently large for some $s$ (larger than $bl/c$) and $f(s) = \theta_H\pi_H(s) - \theta_L\pi_L(s)$ is sufficiently small for this $s$ (smaller than $b^2/2c$).
(ii) $d(s)$ is not that large, but $f(s)$ is small enough, now depending on the value of $d(s)$.

In economic terms, an increase of the educational rate with age would happen if for some age the sum of depreciation ($r$), dequalification ($\delta(s)$) and "learning by doing" ($e(s)$) rates is large relative to the productivity differential $f$. If in a certain age interval the productivity differential is small, this may lead to postponement of learning since in the short run the returns to education are small. The returns to education may be reduced by the fact that people can lose their costly qualification (with rate $\delta(s)$), and can make use of the costless "learning by doing" (with rate $e(s)$). In addition, higher depreciation rate diminishes

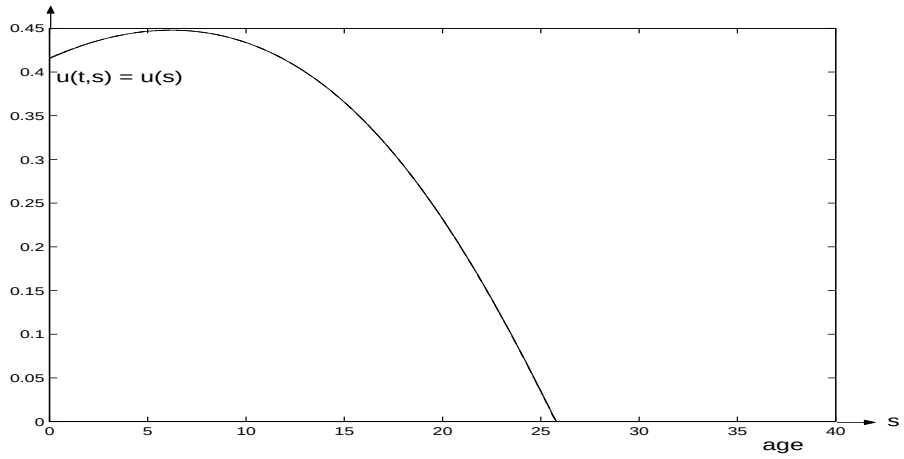


Figure 1: Age distribution of the optimal training rate.

the role of the length of the time-interval in which the worker exercises his qualification, therefore increases the chances for non-monotone learning. We have numerically found the optimal educational policy for the benchmark case presented in Appendix 1. Figure 1 shows that increasing learning with age may happen even when $\delta = e = 0$. We mention that a higher value of $\delta$ can be associated with a higher rate of technological progress. Then higher technological progress may lead to postponement of learning to older ages in order to take advantage of the more advanced knowledge.

*Remark.* As is typical for models with overlapping generations, also in our continuous-age framework the central planner problem decomposes to independent problems at the cohort level, provided that the revenue depends linearly on the production factors. To see this it is enough to observe that for $\rho = \lambda_L = \lambda_H = 1$ the social planner problem takes the form

$$\text{maximize} \int_0^T e^{-rt} \int_0^\omega [\theta_L(t)\pi_L(s)L(t,s) + \theta_H(t)\pi_H(s)H(t,s) - P(t)]\,\mathrm{d}s\,\mathrm{d}t$$

subject to (2), (3) and (7). Then the change of the variables $t = \tau + a$, $s = a$, where $\tau \in [-\omega, T]$, $a \in [\max\{0, -\tau\}, \min\{\omega, T - \tau\}]$, splits the above problem to the following family of independent problems (one for each $\tau \in [-\omega, T)$) with state variables $L^\tau(a), H^\tau(a)$ and control $u^\tau(a) \geq 0$:

$$\text{maximize} \int_{\max\{0,-\tau\}}^{\min\{\omega,T-\tau\}} e^{-ra}[\theta_L(\tau+a)\pi_L(a)L^\tau(a) + \theta_H(\tau+a)\pi_H(a)H^\tau(a) - p(a, u^\tau(a))L^\tau(a)]\,\mathrm{d}a$$

subject to

$$\frac{\mathrm{d}}{\mathrm{d}a}L^\tau(a) = \delta(\tau+a,a)H^\tau(a) - e(a)L^\tau(a) - l(\tau+a,a)u^\tau(a)L^\tau(a),$$
$$\frac{\mathrm{d}}{\mathrm{d}a}H^\tau(a) = -\delta(\tau+a,a)H^\tau(a) + e(a)L^\tau(a) + l(\tau+a,a)u^\tau(a)L^\tau(a)$$

with obvious initial conditions. The relation between the optimal solutions of this decentralized family of problems and the optimal solution of the central planner problem is that $u(\tau+a,a) = u^\tau(a)$ and similarly for $L$ and $H$.

We mention also that considering the continuous age version of the overlapping-generations-type model has the advantages that (i) one can employ analytic tools, such like differentiation with respect to the age, as in the proofs above; (ii) the results are independent of the number of generations (to establish numerically by an overlapping generations model the result we discuss in the next sections one would need to consider at least 6–10 generations).

# 5 Long run effects of the demographic factor in case of imperfect substitutability of labor

The demographic factor is represented in our model by the exogenous inflow of new labor, $N_0(t)$, split into $L_0(t) + H_0(t) = N_0(t)$. Since we assume full employment a change in the demographic factor is equivalent to a change in labor supply. In order to investigate the impact of a demographic change on the optimal educational policy we compare three scenarios: constant, increasing, and decreasing population, by choosing $L_0(t) = L_0e^{\gamma t}$, $H_0(t) = H_0e^{\gamma t}$, where $\gamma$ is zero, positive, or negative growth rate, respectively. Since all the equations in the model and the objective function are homogeneous of first order, the optimal solution is independent of the size of the population. Hence, not the different population sizes are responsible for the different solutions in the three scenarios that we encounter below, rather the differences in the age-distribution of the populations with different growth rates.

The elasticity of substitution across ages for low and for high skilled labor are determined by $\lambda_L$ and $\lambda_H$, respectively. We focus our investigation in this section on how the demographic factor influences the optimal learning rates in different ages in the case of non-perfect substitutability of workers, taking $\lambda_L < 1$ and/or $\lambda_H < 1$. Therefore, in order to shorten the formulas we assume perfect substitutability across qualifications: $\rho = 1$. Moreover, we assume that all data (except for $L_0(t)$ and $H_0(t)$) are time invariant.

We change the variables $L^\gamma(t,s) = e^{-\gamma(t-s)}L(t,s)$, $H^\gamma(t,s) = e^{-\gamma(t-s)}H(t,s)$ in equations (2), (3) (in which the boundary data $L_0(t)$ and $H_0(t)$ are specified as explained above). In fact, $L^\gamma$ and $H^\gamma$ satisfy exactly the same equations (2), (3), only the boundary conditions become

constant: $L_0$ and $H_0$, respectively. Also the initial conditions change correspondingly. We next discuss the long run behaviour of the optimal solution in which the initial data are irrelevant.

Substituting $(L, H)$ by $(L^\gamma, H^\gamma)$ also in equations (4)–(6) and in the objective function (1) we obtain the following equivalent problem:

$$\max \int_0^T e^{-(r-\gamma)t} \left[\theta_L \tilde{L}^\gamma(t) + \theta_H \tilde{H}^\gamma(t) - P^\gamma(t)\right] \mathrm{d}t \tag{18}$$

subject to

$$\begin{aligned}
L^\gamma_t + L^\gamma_s &= \delta(s)H^\gamma(t,s) - e(s)L^\gamma(t,s) - l(s)u(t,s)L^\gamma(t,s), \qquad L^\gamma(t,0) = L_0, && (19)\\
H^\gamma_t + H^\gamma_s &= -\delta(s)H^\gamma(t,s) + e(s)L^\gamma(t,s) + l(s)u(t,s)L^\gamma(t,s), \qquad H^\gamma(t,0) = H_0, && (20)\\
&\quad L^\gamma(0,s),\ H^\gamma(0,s) \text{ – given data,} \\
\tilde{L}^\gamma(t) &= \left(\int_0^\omega e^{-\gamma\lambda_L s}\pi_L(s)(L^\gamma(t,s))^{\lambda_L}\,\mathrm{d}s\right)^{1/\lambda_L}, && (21)\\
\tilde{H}^\gamma(t) &= \left(\int_0^\omega e^{-\gamma\lambda_H s}\pi_H(s)(H^\gamma(t,s))^{\lambda_H}\,\mathrm{d}s\right)^{1/\lambda_H}, && (22)\\
P^\gamma(t) &= \int_0^\omega e^{-\gamma s}p(s,u(t,s))L^\gamma(t,s)\,\mathrm{d}s, && (23)\\
&\quad u(t,s) \geq 0. && (24)
\end{aligned}$$

Thus we obtain that $(L, H, u)$ solves our initial problem with an exponentially changing population ($L_0(t) = L_0 e^{\gamma t}$, $H_0(t) = H_0 e^{\gamma t}$) if and only if $(L^\gamma, H^\gamma, u)$ solves the same problem for a constant population ($L_0(t) = L_0$, $H_0(t)H_0$), but with modified data:

$$\pi^\gamma_L(s) = e^{-\gamma\lambda_L s}\pi_L(s), \quad \pi^\gamma_H(s) = e^{-\gamma\lambda_H s}\pi_H(s), \quad p^\gamma(s,u) = e^{-\gamma s}p(s,u), \quad r^\gamma = r - \gamma.$$

The above simple transformation deserves some comments. First of all we established that the optimal educational policy for an exponentially changing population is exactly the same as for a stationary population with the above modified data. Assume for a moment that $\gamma > 0$. The modified per capita cost of learning, $p^\gamma(s,u)$, decreases with age compared to $p(s,u)$. This does not imply that there would be more learning at old ages, since the efficiency coefficients $\pi^\gamma_L(s)$ and $\pi^\gamma_H(s)$ decrease with $s$, too. However, we point out that $\pi^\gamma_L(s)$ and $\pi^\gamma_H(s)$ decrease with age with different rates. For instance, if $\lambda_H < \lambda_L$, then the efficiency of the high-skilled labor decreases with age less than that of low-skilled labor. This observation leads to the suggestion that for $\gamma > 0$ and $\lambda_H << \lambda_L$ there would be a relative shift of learning from younger to older ages. This means, that the normalized distribution of the optimal learning, $\nu(t,s) = u(t,s)/\int_0^\omega u(t,\sigma)\,\mathrm{d}\sigma$, will be shifted to older ages compared with the stationary case $\gamma = 0$. The situation is similar for a decreasing population ($\gamma < 0$), only

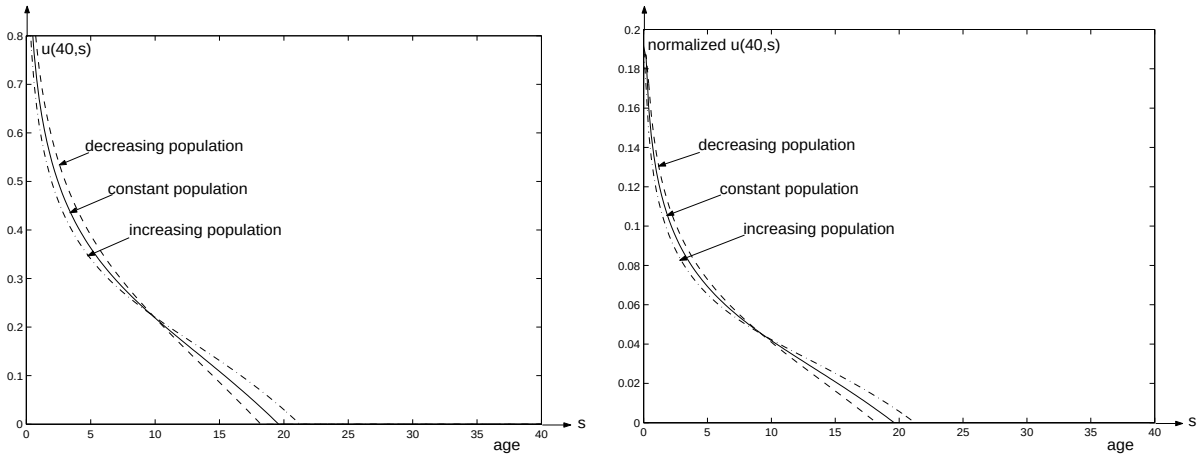


Figure 2: Optimal training rate $u$ (left) and the normalized age-density $\nu$ (right) at $t = 40$ for the three scenarios. Here $\lambda_L = 0.9$, $\lambda_H = 0.1$.

"increase" and "decrease" should be interchanged. This is seen on Figure 2, where $\lambda_H = 0.1$, $\lambda_L = 0.9$. Both the absolute (left plot) and the normalized (right plot) learning rate shift to older ages for the increasing population, and to younger ages for the decreasing population.

The situation is opposite if $\lambda_H >> \lambda_L$. This is clearly supported by Figure 3, which shows that the learning age-density, $\nu$ shifts to older ages if the population decreases, and to young ages if it increases (the right plot gives $\nu(40, \cdot)$). The left plot represents the optimal learning $u(t = 40, s)$ for the three populations showing that in addition to the age-shift there is an increase of learning at all ages for the decreasing population.

Intuitively this change in the age-specific learning rate can be explained as follows. In case of an increasing population the additional labor entering the market would lead to a shift from the optimal age composition for the stationary case towards an excessive amount of young unskilled labor. If the educational rate remains unchanged, then this shift will result in a shift towards lower ages of the age distribution also of skilled labor. Thus keeping the educational rate the same as for the stationary population leads to excessive amount of young workers in both qualification groups. Now we have to distinguish two cases. If $\lambda_H << \lambda_L$, then the distortion of the optimal age distribution of high-skilled labor would be the dominant trouble due to the smaller elasticity of substitution. A counteraction to restore the age-balance of the high-skilled labor is to increase the educational rate for older ages. On the contrary, if $\lambda_H >> \lambda_L$, then it is more important to restore the age distribution of low-skilled labor, since their elasticity of substitution is smaller. The way to do this is to increase learning, more for young ages, which is to decrease the young low-skilled labor by educating it. In case of a decreasing population the arguments are exactly reverse.

Although the theoretical arguments that we presented above are supported by the numerical

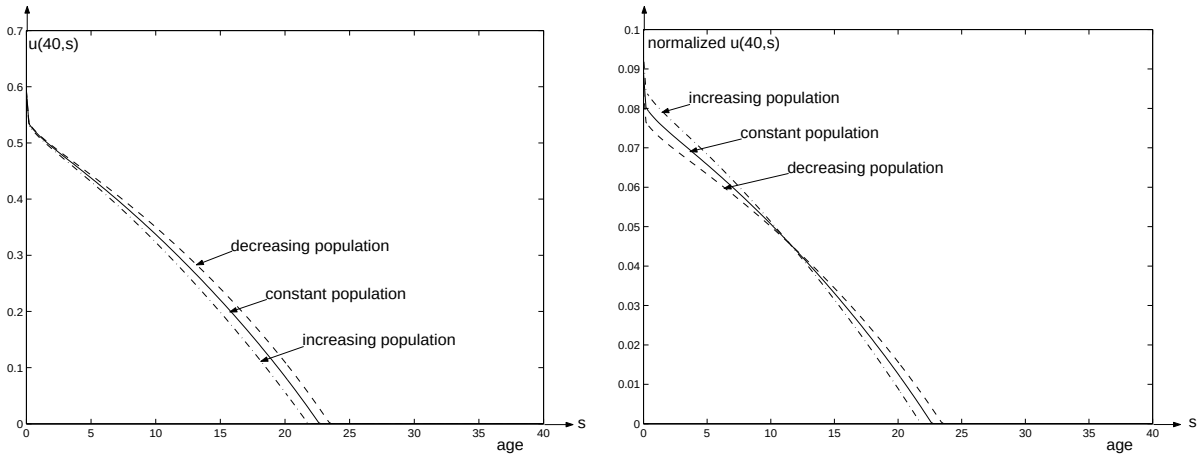


Figure 3: Optimal training rate $u$ (left) and the normalized age-density $\nu$ (right) at $t = 40$ for the three scenarios. Here $\lambda_L = 0.1$, $\lambda_H = 0.9$.

experiments, they do not provide a formal proof of the established dependence of the age-distribution of learning on the demographic factor and the elasticities of substitution. To continue the mathematical analysis we consider the adjoint equation (13) corresponding to the problem (18)–(24), in which we make the substitution $\Delta^\gamma(t,s) = e^{\gamma s}\Delta(t,s)$. Then the equation takes the form

$$\Delta^\gamma_t + \Delta^\gamma_s = (r + e(s) + \delta(s) + l(s)u(t,s))\Delta^\gamma - p(s,u(t,s)) - f^\gamma(t,s), \tag{25}$$

where

$$u(t,s) = p^{-1}_{u+}(s, l(s)\Delta^\gamma(t,s)), \tag{26}$$

and

$$f^\gamma(t,s) = \theta_H \pi_H(s) \left(\frac{e^{\gamma s}\tilde{H}^\gamma(t)}{H^\gamma(t,s)}\right)^{1-\lambda_H} - \theta_L \pi_L(s) \left(\frac{e^{\gamma s}\tilde{L}^\gamma(t)}{L^\gamma(t,s)}\right)^{1-\lambda_L}.$$

Using (21) and (22), the last expression can be rewritten as

$$f^\gamma(t,s) = \theta_H \pi_H(s) \left(\int_0^\omega e^{\lambda_H \gamma(s-\sigma)} \pi_H(\sigma) \left(\frac{H^\gamma(t,\sigma)}{H^\gamma(t,s)}\right)^{\lambda_H} \mathrm{d}\sigma\right)^{\frac{1-\lambda_H}{\lambda_H}}$$
$$-\theta_L \pi_L(s) \left(\int_0^\omega e^{\lambda_L \gamma(s-\sigma)} \pi_L(\sigma) \left(\frac{L^\gamma(t,\sigma)}{L^\gamma(t,s)}\right)^{\lambda_L} \mathrm{d}\sigma\right)^{\frac{1-\lambda_L}{\lambda_L}}.$$

Since in this section we are interested in the long run behavior, we pass to the optimal steady-state system, which is obtained by assuming all functions in equations (19)–(26) independent

of $t$. We keep the same notations $L^\gamma$, $H^\gamma$, etc., in which the argument $t$ is skipped. To show in a more transparent way how one could make use of the above formula for the productivity differential in the analysis of the long run behavior of the optimal educational policy, we take first the simpler specifications: $\delta(s) = e(s) = 0$, $\lambda_H = 1$, $\lambda_L < 1$, $p(s,u) = \frac{c}{2}u^2$. Also, we assume here that the control constraint $u \geq 0$ is not binding, which, due to the specific form of $p(s,u)$, is equivalent to assuming that for each $(t,s)$ the shadow price of a high-skilled worker is larger than the shadow price of a low-skilled one. Then we have

$$L^\gamma(s) = e^{-\int_0^s l(\theta)u^\gamma(\theta)\,\mathrm{d}\theta} L_0, \qquad u^\gamma(s) = p_{u+}^{-1}(s, l(s)\Delta^\gamma(s)) = \frac{l(s)}{c}\Delta^\gamma(s),$$

and after obvious transformations the formula for $f^\gamma(s)$ takes the form

$$f^\gamma(s) = \theta_H \pi_H(s) - \theta_L \pi_L(s) \left( \int_0^\omega \pi_L(\sigma) e^{\lambda_L \int_\sigma^s (\gamma + l(\theta)u^\gamma(\theta))\,\mathrm{d}\theta}\,\mathrm{d}\sigma \right)^{\frac{1-\lambda_L}{\lambda_L}}.$$

Since $u^\gamma(s) = \frac{l(s)}{c}\Delta^\gamma(s)$, we obtain the adjoint equation in the feed-back form

$$\dot{\Delta}^\gamma(s) = r\Delta^\gamma(s) + \frac{(l(s))^2}{2c}\left(\Delta^\gamma(s)\right)^2 - \bar{f}^\gamma(s, \Delta^\gamma(\cdot)), \tag{27}$$

where

$$\bar{f}^\gamma(s, \Delta^\gamma(\cdot))\theta_H \pi_H(s) - \theta_L \pi_L(s) \left( \int_0^\omega \pi_L(\sigma) e^{\lambda_L \int_\sigma^s \left(\gamma + \frac{(l(\theta))^2}{c}\Delta^\gamma(\theta)\right)\,\mathrm{d}\theta}\,\mathrm{d}\sigma \right)^{\frac{1-\lambda_L}{\lambda_L}}. \tag{28}$$

Due to the form of the functional $\bar{f}^\gamma$, where $\Delta^\gamma$ appears integrated, equation (27) is still a complicated integral-differential equation which is difficult to analyze. However, we are only interested in the qualitative dependence of $\Delta^\gamma$ on $\gamma$, in comparison to the case $\gamma = 0$. Therefore we pass to its first order approximation (with respect to $\gamma$, which is presumably a "small" number). Namely, we denote the marginal change of the difference in the shadow price of high- and low- skilled workers w.r.t. $\gamma$ as follows

$$\Gamma(s) = \frac{\mathrm{d}\Delta^\gamma}{\mathrm{d}\gamma}(s),$$

where the derivative is evaluated at $\gamma = 0$. Differentiating (27) with respect to $\gamma$ we obtain the following linear integral-differential equation for $\Gamma$:

$$\Gamma'(s) = r\Gamma(s) + \frac{(l(s))^2}{c}\Delta^0(s)\Gamma(s) - \frac{\mathrm{d}\bar{f}^\gamma(s, \Delta^\gamma(\cdot))}{\mathrm{d}\gamma}, \quad \Gamma(\omega) = 0. \tag{29}$$

From (28) we easily obtain the following expression for the last term for $\gamma = 0$:

$$\frac{\mathrm{d}\bar{f}^\gamma(s, \Delta^\gamma(\cdot))}{\mathrm{d}\gamma} = -\zeta(s) \int_0^\omega \varphi(\sigma) \int_\sigma^s \left(1 + \frac{(l(\theta))^2}{c}\Gamma(\theta)\right)\,\mathrm{d}\theta\,\mathrm{d}\sigma,$$

where

$$\varphi(\sigma) = \pi_L(\sigma)\lambda_L e^{\lambda_L \int_\sigma^s \frac{(l(\theta))^2}{c}\Delta^0(\theta)\,\mathrm{d}\theta},$$

and we skip the long expression for $\zeta$, from which it is only important that $\zeta(s) > 0$. Splitting the integral $\int_0^\omega = \int_0^s + \int_s^\omega$ in the second last formula and changing the order of integration in the two integrals we obtain

$$\begin{aligned}\frac{\mathrm{d}\bar{f}^\gamma(s,\Delta^\gamma(\cdot))}{\mathrm{d}\gamma} = &-\zeta(s)\left[\int_0^s \left(1+\frac{(l(\theta))^2}{c}\Gamma(\theta)\right)\left(\int_0^\theta \varphi(\sigma)\,\mathrm{d}\sigma\right)\mathrm{d}\theta\right.\\ &\left.-\int_s^\omega \left(1+\frac{(l(\theta))^2}{c}\Gamma(\theta)\right)\left(\int_\theta^\omega \varphi(\sigma)\,\mathrm{d}\sigma\right)\mathrm{d}\theta\right].\end{aligned}$$

Plugging the obtained expressions in (29) and using the notation

$$\psi(s,\theta) = \begin{cases} \int_0^\theta \varphi(\sigma)\,\mathrm{d}\sigma & \text{if } \theta \le s \\ -\int_\theta^\omega \varphi(\sigma)\,\mathrm{d}\sigma & \text{if } \theta > s, \end{cases}$$

we obtain the following form of the equation for $\Gamma$:

$$\Gamma'(s) = r\Gamma(s) + \frac{(l(s))^2}{c}\Delta^0(s)\Gamma(s) + \zeta(s)\int_0^\omega \psi(s,\theta)\left(1+\frac{(l(\theta))^2}{c}\Gamma(\theta)\right)\mathrm{d}\theta, \quad \Gamma(\omega) = 0. \tag{30}$$

This is still a complicated integral-differential equation, but it allows to prove (see Appendix 2) the following result.

**Proposition 3** *The solution $\Gamma$ of equation (30) has the following form: there exists $\bar{s} < \omega$ such that $\Gamma(s) \ge 0$ on $[0,\bar{s}]$ and $\Gamma(s) < 0$ on $(\bar{s},\omega)$. It may happen that $\bar{s} < 0$, that is, $\Gamma(s) < 0$ for all $s \in (0,\omega)$.*

*Economic interpretation of Proposition 3.* If the high-skilled labor is perfectly substitutable across ages ($\lambda_H = 1$) and the low-skilled labor is not ($\lambda_L < 1$), then in the long run the optimal learning rate $u(s)$ of an increasing population is lower (except possibly an interval of young ages, $[0,\bar{s})$ with $\bar{s} < \omega$) than that for a stationary or decreasing population. Conversely, a decreasing population has higher learning rate, at least for older ages.

Notice that in our numerical test with $\lambda_L = 0.1$ and $\lambda_H = 0.9$ the decreasing population learns more, and the increasing population learns less than the stationary population at all ages for which $u > 0$ (the left plot in Figure 3).

The other "extreme" case, $\lambda_L = 1$, $\lambda_H < 1$ is technically more complicated and we do not present its analysis. As Figure 2 (left plot) shows the effect of the demography on learning at older ages is just the opposite in this case, compared with the case $\lambda_L = 0.1$, $\lambda_H = 0.9$. However, for young ages the increasing population learns less in both cases.

The situation complicates even more if both the high-skilled and the low-skilled labor are not perfectly substitutable across ages. Here the relation between $\lambda_L$ and $\lambda_H$ plays a role for the qualitative dependence of the optimal learning rate on the demography in the same direction as in the two "extreme" cases considered above. However, if both $\lambda_L$ and $\lambda_H$ are strictly smaller than one, and if the difference between them is "small", then the particular data $\theta_L$, $\theta_H$, $\pi_L(s)$ and $\pi_H(s)$ may have a decisive role for the qualitative impact of the demography on the optimal educational policy.

# 6 Short run and anticipation effects of a demographic change

In this section we investigate (theoretically and numerically) the short run effects of a demographic change on the optimal learning rate. That is, if a stationary population begins to increase or decrease, how this demographic change would influence the optimal educational rate shortly after the change took place. Moreover, we establish that in case of imperfect substitutability of labor (either across ages or across qualifications) a change in the demographic factor influences the optimal education policy not only afterwards but also before the change takes place. That is, contrary to the case of perfect substitutability of labor, here the expectation of a future change in the supply of labor influences the human capital building even before the labor market becomes affected by this change.

We start with the three scenarios from the previous section—constant, increasing, and decreasing population—by choosing a constant growth rate $\gamma$, where $\gamma$ is zero, positive, or negative, respectively. We then assume that till the year $\bar{t} = 20$ the population is stationary in all the three scenarios, while starting at time $\bar{t} = 20$ the three populations grow differently: $N_0(t) = N_0 e^{\gamma(t-\bar{t})}$ for $t > \bar{t}$. We shall compare the optimal learning rate in the three scenarios at time $t \in [\bar{t}, \bar{t}+\omega)$ (that is, shortly after the growing/shrinking population enters the labor market), but also at time $t < \bar{t}$, when the labor market is still not affected by the demographic change, but is already aware of this future change in labor supply. In the numerical results presented below[5] the constant size population is simulated numerically before time $t = 0$, and the end time $T$ is sufficiently large (we have used $T = 180$) so that the optimal solution for the constant scenario is close to the steady state (does not change with time in the interval $(0, 30)$). We have chosen $\lambda_L = 0.9$, $\lambda_H = 0.1$, (alternatively $\lambda_L = 0.1$, $\lambda_H = 0.9$), $\gamma = 0$ or $\gamma = \pm 0.0072$ in the three scenarios, the rest of the data is as in the benchmark case specified in Appendix 1.

[5] The numerical solution is itself a challenging issue (this applies also to the previous sections). In our numerical analysis we use the general solver for age-structured optimal control problems developed by the third author, which is very briefly described in (Feichtinger et al. 2004). A detailed description will be given in a forthcoming paper of the third author.

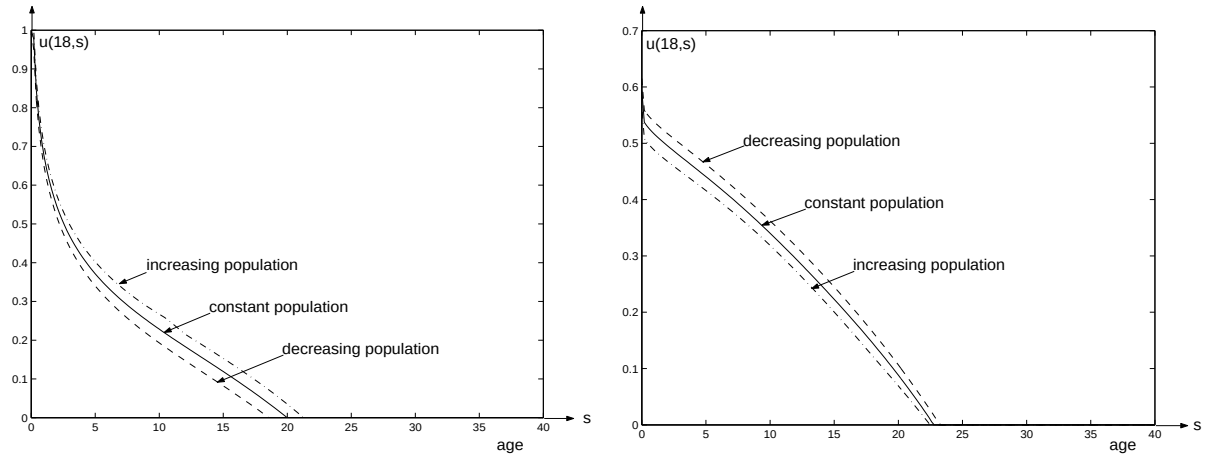


Figure 4: Age distribution of the optimal training rate in the anticipation phase ($t = 18$) for the three scenarios and for $\lambda_L = 0.9$, $\lambda_H = 0.1$ (left plot) and $\lambda_L = 0.1$, $\lambda_H = 0.9$ (right plot).

Figure 4 presents the age distribution of the optimal education rate at $t = 18$ (two years before the demographic change starts to influence the labor market). The expectation of an increasing/decreasing population leads to a change in the optimal education rate before (in fact, also shortly after) the change at time $\bar{t} = 20$. The direction of change is different for different combinations of $\lambda_L$ and $\lambda_H$. We see on the left plot of Figure 4 that if $\lambda_H = 0.1 < 0.9 = \lambda_L$, then the expectation of increasing population leads to higher education rate before the time of change, while for the decreasing population the education rate is lower. The situation is just the opposite for $\lambda_L = 0.1 < 0.9 = \lambda_H$ (the right plot).

The anticipation effect is not restricted just to the few years before $\bar{t}$. In Figure 5 we plot the time-path of the aggregate per capita education effort, defined as $\int_0^\omega L(t,s)u(t,s)\,\mathrm{d}s / \int_0^\omega N(t,s)\,\mathrm{d}s$. Since the population before $\bar{t}$ is of the same size for all $t$, this is a relevant indicator for the educational effort. Clearly, the educational effort is highest for the population for which the labor market is expected to expand at $\bar{t}$ and this happens in the whole plotted interval (at least 20 years before the demographic change results in a change of the labor supply).

Now we pass to the mathematical proof of the anticipation effect discussed above. To simplify somewhat the consideration we compare the following two scenarios: the constant inflow case, $N_0(t) = N_0$, and

$$N_0(t) = N_0^*(t) = \begin{cases} N_0 & \text{for } t \le \bar{t}, \\ N_0^* & \text{for } t > \bar{t}, \end{cases}$$

where $N_0^* > N_0$ (the case $N_0^* < N_0$ can be treated in the same way). We shall assume that the upward jump in the population at (economically active) age $s = 0$ is afecting only the

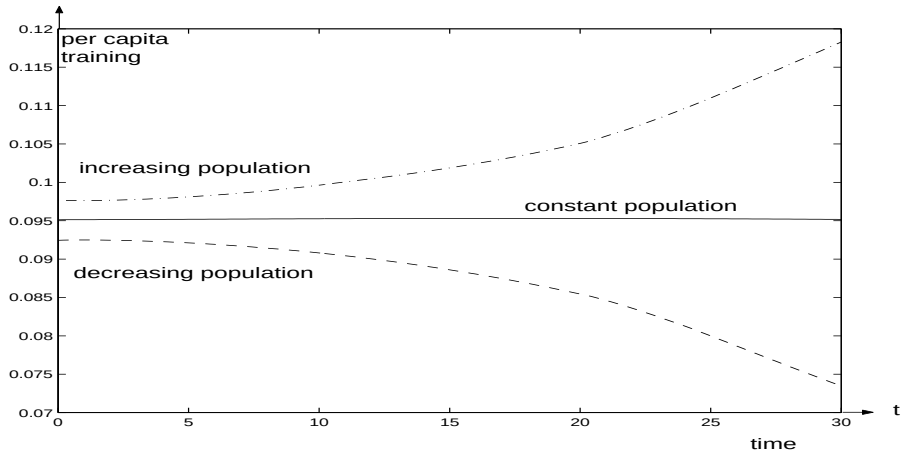


Figure 5: Per capita training effort in the anticipation phase ($t \in [0, 30]$) for the three scenarios, and for $\lambda_L = 0.9$, $\lambda_H = 0.1$.

low-skilled workers: $N_0^*(t) = L_0^*(t) + H_0^*(t)$ where

$$L_0^*(t) = \begin{cases} L_0 & \text{for } t \leq \bar{t}, \\ L_0^* & \text{for } t > \bar{t}, \end{cases}$$

with $L_0^* > L_0$, and $H_0^*(t) \equiv H_0 > 0$ for $t \in [0, T]$. Although the scenario $N_0^*$ is different from the scenario with exponentially increasing population $N_0(t) = N_0 e^{\gamma(t-\bar{t})}$, $\gamma > 0$, considered in the numerical experiment, both scenarios have the same effect on the population change shortly after $\bar{t}$: in both cases the age distribution of the population shifts to lower ages in the time interval $[\bar{t}, \bar{t} + \omega)$. As we have already mentioned in Section 5, it is this shift that determines the policy change (before or after the demographic change) rather than the difference in the absolute size of the population, which plays no role.

In the proposition below we restrict the consideration to the case of imperfect substitutability between different qualifications ($\rho < 1$), while $\lambda_L = \lambda_H = 1$. The case of imperfect substitutability across ages is analytically more difficult and is enlightened only by the numerical results.

Denote by $u(t, s)$, $L(t, s)$, $H(t, s)$ the optimal path for the scenario with stationary demography, and by $u^*(t, s)$, $L^*(t, s)$, $H^*(t, s)$ – the optimal path for the $N_0^*(t)$ scenario for the demography.

**Proposition 4** *Assume the following: (i) $\bar{t} > \omega$; (ii) there exists $s_0 \in (0, \omega)$ such that $u(t, s) > 0$ for $s \in [0, s_0]$ and $t < \bar{t}$. Then there exist $(t, s)$ with $t < \bar{t}$ such that $u^*(t, s) > u(t, s)$.*

At first glance the conclusion of the proposition may seem rather weak: it claims that the "positive" anticipation of the future growth of the working population may happen to be exhibited just at a single moment of time $t < \bar{t}$ and a single age $s$. The lemma below implies that this happens, in fact, in a "solid" set $[t', t''] \times [s', s''] \in (0, \bar{t}) \times [0, \omega]$ of times and ages. On the other hand, it is certainly not true that the anticipation is positive (that is, $u^*(t, s) > u(t, s)$) for all $t < \bar{t}$ and $s \in [0, \omega]$ since clearly it may happen that (i) $u^*(t, s) = u(t, s) = 0$ for old ages $s$.

**Lemma 1** *The optimal training rates $u$ and $u^*$ are continuous functions. In addition both $u$ and $u^*$ are bounded functions.*

The proofs of the proposition and of the lemma are given in Appendix 2.

We established above, theoretically and numerically, that a change of the learning rate takes place in the case of increasing/decreasing population even before the demographic change starts affecting the labor market. What is the economic reason for this effect?

**A.** Let us consider first the case of imperfect substitutability of high-skilled and low-skilled labor ($\rho < 1$), treated by Proposition 4. Since the additional labor that enters the labor market after the beginning of the demographic change at time $\bar{t}$ is of low-skilled labor, the optimal balance between high-skilled and low-skilled labor will be violated by an exceeding amount of low-skilled labor. Due to the imperfect substitutability across qualifications, in order to restore the optimal balance, the learning rate should be increased. Due to the increasing marginal cost of learning, the cost per unit of learning rate would become higher than before the demographic change, if the learning rate for $t < \bar{t}$ were not increased. On the other hand, the young high-skilled labor at time $t$ before and close to $\bar{t}$ would remain high-skilled labor also after $\bar{t}$. Then at the optimum a part of the additional learning rate after the demographic change would be shifted to the years before the change, in order to take advantage of the lower learning cost. This is the positive anticipation effect.

**B.** In case of imperfect substitutability of labor across ages ($\lambda_L < 1$, $\lambda_H < 1$, $\rho = 1$) the same intuitive reasoning applies as we discussed in Section 5 on the long run behavior of the optimal learning rate. Then the anticipation effect (Figure 4 represents actually the anticipation phase) follows from the same reasoning as in part **A**: shifting some of the educational efforts to times before $\bar{t}$ (smoothing in this way the learning rate) decreases the costs of education.

In the case when $\lambda_H$ and $\lambda_L$ are both less than one and relatively close to each other, the same comment applies as in the end of Section 5.

If we put together some of the short and the long run analysis from this and from the previous section we observe the following effects that the growth of the population has on

the quantity and age-structure of the optimal educational policy (compared with a stationary population).

(i) In case of a small elasticity of substitution of low-skilled labor across age (relative to that of high-skilled labor) the increasing population learns less than the stationary one at all ages (cf. the left plot in Figure 3 and the right plot in Figure 4). The age-distribution of learning is shifted to younger ages in the long run (cf. the right plot in Figure 3).

(ii) In case of a small elasticity of substitution of high-skilled labor across age (relative to that of low-skilled labor) the increasing population learns more than the stationary one at older ages (cf. the left plot in Figure 2 and the left plot in Figure 4). The age-distribution of learning is shifted to older ages in both phases (cf. the right plot in Figure 2 and the left plot in Figure 4).

In case of a decreasing population we observe similar behavior with all the changes in the opposite direction.

The above analysis clearly exhibits the importance of the relation between the elasticity of substitution across ages of high-skilled and of low-skilled labor, which may lead to different (opposite) impact of the demographic changes on the optimal educational policy.

# 7 Changing returns to education and its relation to demographic change

In this section we define unskilled workers as those with at most high school and skilled as those with at least a college.

Assume now that the labor force is efficiently utilized. This means that the wages equal the marginal productivities. Then, after the optimization problem is solved, we can calculate the resulting age $s$ and time $t$ specific wages $w_L(t,s)$ and $w_H(t,s)$ from the respective marginal productivities.

Assuming that wages equal marginal productivity of labor and following the approach as in (Card and Lemieux 2001) the age and time specific differential in the logarithmic wage of high- and low-skilled workers can be expresses as follows:

$$r(s,t) = \log w_H - \log w_L = \log\left(\frac{\theta_H}{\theta_L}\right) + \log\left(\frac{\pi_H}{\pi_L}\right) + \frac{1}{\sigma_Y}(\log \tilde{L}(t) - \log \tilde{H}(t)) + \frac{1}{\sigma_H}(\log \tilde{H}(t) - \log H(t,s)) - \frac{1}{\sigma_L}(\log \tilde{L}(t) - \log L(t,s)),$$

where $\sigma_L = 1/(1-\lambda_L)$, $\sigma_H = 1/(1-\lambda_H)$ and $\sigma_Y = 1/(1-\rho)$ are the elasticities of substitution across ages of low-skilled and high-skilled labor, and across qualifications, respectively. Note that the case of perfect substitutability of workers of different ages within each educational category correspond to taking the limit $\sigma_L \to \infty$ and $\sigma_H \to \infty$. Then the wage differential will only depend on the aggregate composition of high and low-skilled workers, $\tilde{L}$ and $\tilde{H}$, and not on the age-group specific supply of high and low skilled workers. In addition, if the elasticity of substitution across skill groups is also infinite, then the wage differential depends only on $\theta_H/\theta_L$ and $\pi_H/\pi_L$, which complies with Proposition 1 in Section 4.

The two plots in Figures 6 represent the productivity (wage) differential, $w_H(t,s) - w_L(t,s)$, for increasing/stationary/decreasing populations with imperfect substitutability of labor across ages: $\lambda_L = 0.9$, $\lambda_H = 0.1$. It is remarkable that the dependence of the productivity (wage) differential on the demography in the anticipation/transition phase ($t = 18$) and in the steady-state ($t = 40$) is qualitatively the same. Namely, in both phases we observe *higher wage differentials in young ages for a decreasing population, and lower ones for an increasing population.*

As we stressed several times above, not the absolute size of the population, rather its age-distribution is responsible for the influence of the demography on the composition of labor across age and qualification. On the other hand, an increasing population has a younger age-distribution (lower average age) than a stationary or decreasing one, and the opposite is true for a decreasing population. Thus we may reformulate the above finding in the following way:

*If the average age of labor is lower, the wage differential in young ages is lower, and vice versa.*

Our normative model therefore provides an explanation of the evolution of the wage differentials for young male workers in the USA in the period 1960–1990 similar to the positive economic model set up as presented in Card and Lemieux (2001). The left plot on Figure 7 represents a smoothed version of the data for the wage differentials for young male workers published in the above mentioned paper. The right plot represents the average age of labor (20–65 years old population). The latter figure is a smoothing of data extracted from (United Nations 2004). Both plots have three intervals of monotonicity. Although there are small shifts in the times of minimal and maximal wage differentials versus average age of labor in the two figures, we point out that:
(i) in the years before 1963 both the average age of labor and the wage differential are increasing;
(ii) in the years 1967–1978 both the average age of labor and the wage differential are decreasing (the former, due to the baby-boom in USA some 20 years earlier);
(iii) in the years 1984–1995 both the average age of labor and the wage differential are increasing (the former, due to the ageing of the baby-boom cohort).

The slight differences in the qualitative bahavior (increase/decrease) in the empirical data seen in Figure 7 and in our predictions may have many reasons: (i) the average age used

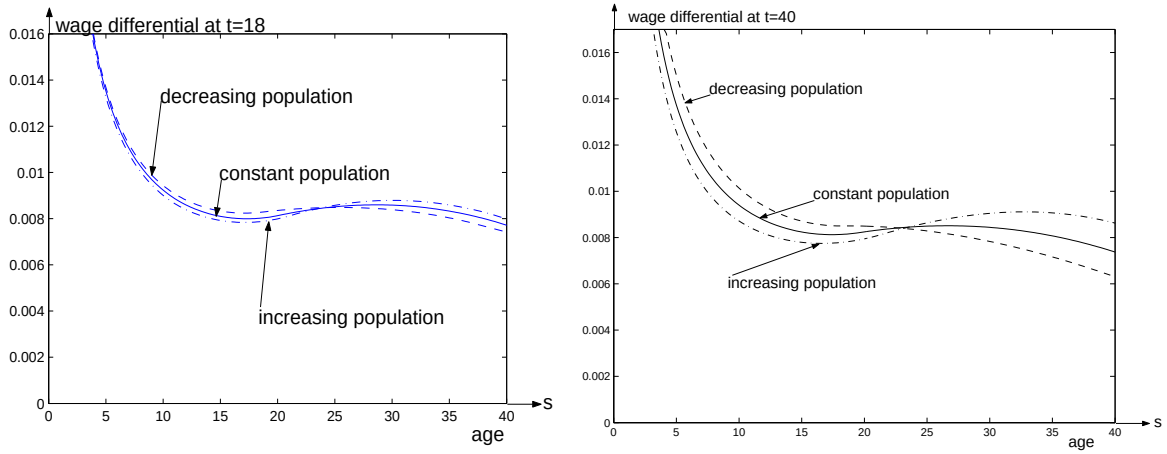


Figure 6: Productivity (wage) differentials for increasing, stationary and decreasing populations and for $\lambda_L = 0.9$, $\lambda_H = 0.1$: in the anticipation/transition phase $t = 18$ (left plot), and in the steady-state phase, $t = 40$ (right plot).

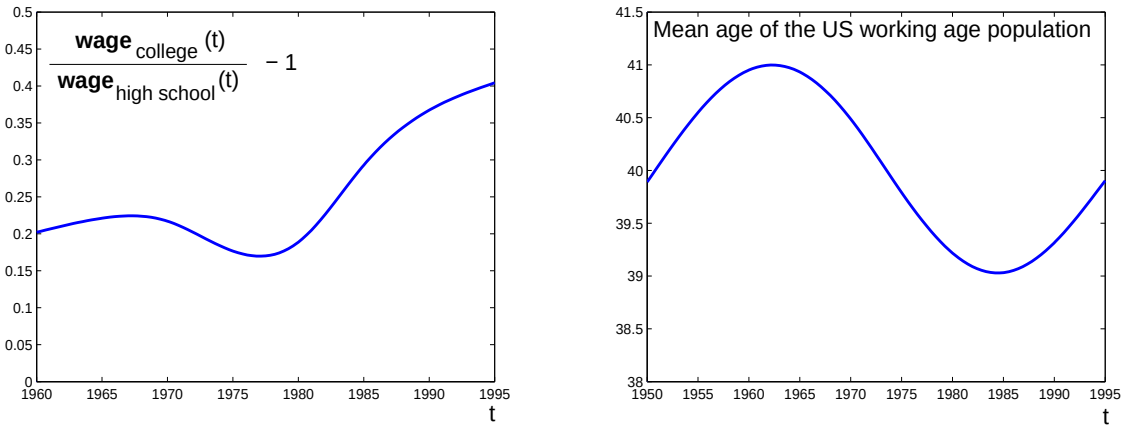


Figure 7: The (normalized) wage differentials for young male workers in the USA (left plot) and the mean age of working age (20-65 years) population (right plot).

in Figure 7 is only a rough indicator for the age structure of the population, on which the results of our model depend; (ii) additional factors such as migration, differences in the optimal solution for the central planer from the decisions of the economic agents in a market driven economy, etc.

For the qualitative replication of the evolution of the wage differential presented above it was crucial to assume that the elasticity of substitution across ages of the unskilled labor is higher than that for skilled labor, $\lambda_L > \lambda_H$. According to Stapleton and Young (1988) there is an empirical evidence for this assumption.

# 8 Conclusions

Skill and age heterogeneity have only rarely been integrated into formal macro-economic models. However, such models constitute the framework for a normative analysis of the optimal age- and education-specific labor force. The aim of our paper is to provide a formal model of the optimal education policy at the macro level allowing for heterogeneity of the workforce with respect to its age and qualification skills. Within this framework we study the optimal education rate in the context of changes in the labor demand (as represented by the elasticity of substitution across ages and qualification) and labor supply (as represented by the population growth rates).

We establish a number of numerical and analytical results on the optimal age-specific training rate. In case of perfect substitutability of labor across age and qualification we show that the optimal age-specific training rate is independent of labor supply. Once we allow for imperfect substitutability of workers across age and qualification the optimal training rate depends on labor demand as well as labor supply factors. The analysis clearly exhibits the importance of the relation between the elasticities of substitution across ages of skilled and unskilled labor, which may lead to different (opposite) impacts of the demographic change on the optimal educational policy. As these results indicate, the relation between the elasticities of substitution of labor across ages plays a crucial role for the way the demographic changes affect (both in the short and in the long run) the optimal educational policy. A further interesting result we obtained is the anticipation of future changes in labor supply. Already several years in advance of the time when the actual change takes place the optimal educational rate will change.

Various extensions of our analysis are promissing . Our production technology depends only on labor. An obvious extension of our framework is to allow for physical capital in addition to human capital. So far we assumed a relatively simple educational process only implicitly taking into account the fact that people in education might not be active full time in the labor market. These assumptions as well as the assumption of full employment could be relaxed in further extensions of our model. So far, we assume labor supply—as represented by the

demographic change—to be exogenous, but human capital composition will affect fertility and mortality. The interdependence of education, fertility and human capital (similar as in (Connelly and Gottschalk 1995)) could be studied. The assumption of the CES production function within each educational aggregate is restrictive as well. When workers from one age group are substituted by members of any other age group, the actual age difference does not matter. As it was recently indicated in (Prskawetz et al. 2008) the production function could be extended to allow for a more flexible pattern of the substitutability of workers across ages.

# Appendix 1: Benchmark data specification

In the numerical experiments we have used the following benchmark data setting:

$\omega = 40$ – age of retirement minus initial working age $a^0 = 20$;
$T = 140$ – end of the time interval;
$[45, 95]$ – the time interval used for the plots;
$\delta(t, s) \equiv 0$ – there is no decay of the human capital;
$e(s) \equiv 0$ – there is no learning by doing;
$l(t, s) \equiv 0.1386$ – constant in age and time efficiency of learning;
$\theta_L(t) \equiv 0.3,\ \theta_H(t) \equiv 0.7$;
$p(s, u) \equiv p(u) = \frac{9}{520}u + \frac{3}{260}u^2$ – the cost of educating one low-skilled worker if the educational effort is at level $u$;
$\rho = 1$ – the aggregate low- and aggregate high-skilled labor are perfect substitutes;
$\lambda_L$ – the different values are specified in the respective sections and figure captions;
$\lambda_H$ – the different values are specified in the respective sections and figure captions;
$r = 0.03$ – discount rate;
$\bar{\pi}_L(s) = c_L \exp(\frac{q_1^2}{(s-m_L)^2 - q_2^2}),\quad \bar{\pi}_H(s) = c_H \exp(\frac{q_1^2}{(s-m_H)^2 - q_2^2})$ are age-specific productivities of low-skilled and high-skilled workers (the functional form is taken from (Prskawetz and Veliov 2007), where the parameters are identified using data from France, 1998);
$\pi_L(s) = \frac{\bar{\pi}_L(s)}{\int_0^\omega \bar{\pi}_L(\sigma)d\sigma},\quad \pi_H(s) = \frac{\bar{\pi}_H(s)}{\int_0^\omega \bar{\pi}_H(\sigma)d\sigma}$ are age-specific relative efficiency parameters in the CES functions for the low- and high-skilled aggregate labor;
$c_L = 500$, $c_H = 1000$ – scaling factors,
$m_L = 13$, $m_H = 20$ – age of maximal productivity,
$q_1 = 100$, $q_2 = 60$ – parameters identified from data;
$L_0(t) \equiv 1000,\ H_0(t) \equiv 10^{-6}$ – the inflow of low- and high-skilled workers at the initial working age in the constant population scenario;
$L_0(t) = 1000 \exp(0.0072(t-45)),\ H_0(t) = 10^{-6}\exp(0.0072(t-45))$ – the inflow of low- and high-skilled workers at the initial working in the increasing population scenario;
$L_0(t) = 1000 \exp(-0.0072(t-45)),\ H_0(t) = 10^{-6}\exp(-0.0072(t-45))$ – the inflow of low- and high-skilled workers at the initial working age in the decreasing population scenario.

# Appendix 2

In this appendix we present some technical proofs. In the analysis of the optimal solution we implicitly assume also that the solution is unique, and that the necessary optimality condition (maximum principle) presented in Section 3 is also a sufficient condition. This assumption is automatically fulfilled if the mapping "control $u \longrightarrow$ objective value" is strongly convex, for which there is a strong evidence. However, this purely mathematical issues go beyond the scope of the present paper.

**Proof of Proposition 3.** Let $s^* \in [0, \omega]$ be a point such that $\Gamma(s^*) \geq 0$. There exists a maximal interval $[s_1, s_2] \subset [0, \omega]$ containing $s^*$ such that $\Gamma(s) \geq 0$ on $[s_1, s_2]$. We consider two cases.

(i) Assume that $0 < s_1 < s_2$. Since $\Gamma(\omega) = 0$, clearly we have $\Gamma(s_1) = \Gamma(s_2) = 0$. Then

$$\Gamma'(s_1) \geq 0, \quad \text{and } \Gamma'(s_2) \leq 0.$$

We have $Q(\theta) = 1 + \frac{(l(\theta))^2}{c}\Gamma(\theta) > 0$ for $\theta \in [s_1, s_2]$. Moreover

$$0 \leq \Gamma'(s_1) = \zeta(s_1) \int_0^\omega \psi(s_1, \theta) Q(\theta)\, \mathrm{d}\theta,$$

which implies

$$\int_0^\omega \psi(s_1, \theta) Q(\theta)\, \mathrm{d}\theta \geq 0,$$

since $\zeta(s) > 0$. Then

$$\begin{aligned}
\frac{\Gamma'(s_2)}{\zeta(s_2)} &= \int_0^\omega \psi(s_2, \theta) Q(\theta)\, \mathrm{d}\theta \\
&= \int_0^{s_2} \int_0^\theta \varphi(\sigma)\, \mathrm{d}\sigma Q(\theta)\, \mathrm{d}\theta - \int_{s_2}^\omega \int_\theta^\omega \varphi(\sigma)\, \mathrm{d}\sigma Q(\theta)\, \mathrm{d}\theta \\
&= \left( \int_0^{s_1} + \int_{s_1}^{s_2} \right) \int_0^\theta \varphi(\sigma)\, \mathrm{d}\sigma Q(\theta)\, \mathrm{d}\theta - \left( \int_{s_1}^\omega - \int_{s_1}^{s_2} \right) \int_\theta^\omega \varphi(\sigma)\, \mathrm{d}\sigma Q(\theta)\, \mathrm{d}\theta \\
&= \int_0^\omega \psi(s_1, \theta) Q(\theta)\, \mathrm{d}\theta + \int_{s_1}^{s_2} \int_0^\omega \varphi(\sigma)\, \mathrm{d}\sigma Q(\theta)\, \mathrm{d}\theta \\
&> \int_0^\omega \psi(s_1, \theta) Q(\theta)\, \mathrm{d}\theta \geq 0,
\end{aligned}$$

where we use that $Q(\theta) > 0$ on $[s_1, s_2]$ and $\int_0^\omega \varphi(\sigma)\, \mathrm{d}\sigma > 0$. Thus $\Gamma'(s_2) > 0$. This is a contradiction, which proves that case (i) is impossible. This implies, in particular, that there is no maximal open interval $(s_1, s_2) \subset [0, \omega]$ in which $\Gamma(s) > 0$ with $s_1 > 0$.

(ii) $0 < s_1 = s_2 = s^*$. In this case $\Gamma(s^*) = 0$ and $\Gamma'(s^*) = 0$. Since $\Gamma(s)$ is close to zero in a neighborhood $(s', s'')$ of $s^*$, we have $Q(s) > 0$ in $(s', s'')$. Due to the conclusion in the case (i) we have $\Gamma(s) \leq 0$ in $(s', s'')$. Then there exist points $s_1 < s^* < s_2$ in $(s', s'')$ for which $\Gamma'(s_1) \geq 0$, $\Gamma'(s_2) \leq 0$. This leads to a contradiction exactly in the same way as in case (i).

Thus we obtain that $[s_1, s_2] = [0, s_2]$. To complete the proof of the claim we observe that the case $s_2 = \omega$ is not possible, since in this case $\Gamma'(\omega) > 0$ due to (30) and this implies $\Gamma(s) < 0$ for $s$ close to $\omega$. Q.E.D.

**Proof of Lemma 1.** For $\lambda_L = \lambda_H = 1$ equation (13) for the adjoint variable $\Delta$ takes the form

$$\begin{aligned} \Delta_t + \Delta_s = {} & (d(t,s) + l(t,s)u(t,s))\Delta - p(s, u(t,s)) - f(t,s), \\ & \Delta(t,\omega) = 0, \quad \Delta(T,s) = 0, \end{aligned} \tag{31}$$

where

$$u(t,s) = p_{u+}^{-1}(s, l(t,s)\Delta), \qquad d(t,s) = r + e(s) + \delta(t,s) \tag{32}$$

and

$$f(t,s) = \theta_H(t)\pi_H(s)\left(\frac{Y(t)}{\tilde{H}(t)}\right)^{1-\rho} - \theta_L(t)\pi_L(s)\left(\frac{Y(t)}{\tilde{L}(t)}\right)^{1-\rho}$$

Due to the standing assumptions the aggregated states $Y(t)$, $\tilde{L}(t)$ and $\tilde{H}(t)$ are continuous, as it could be easily obtained from the absolute continuity of the solution of equations (2), (3) along the characteristic lines (although $u$ might be discontinuous, a priori). The function $\Delta \longrightarrow p_{u+}^{-1}(s, l(t,s)\Delta)$ is Lipschitz continuous, due to the uniform strong convexity of $p(s,\cdot)$. Then equation (31) with $u$ substituted from (32) has a Lipschitz right-hand side with respect to $\Delta$. Moreover, the side conditions for this equation are also continuous (identically zero). Then continuity of $\Delta$ follows from the classical result for continuous dependence of the solution of continuously parameterized family of ODEs on the parameter. The argument is, that (31) is such a family, parameterized by the part of the boundary where the side conditions are given. Then the continuity of $u$ follows from (32). Q.E.D.

**Proof of Proposition 4.** We only sketch the proof leaving many details to the diligent reader. We assume that $u^*(t,s) \leq u(t,s)$ for every $t \leq \bar{t}$ and $s \in [0,\omega]$, which will bring us to a contradiction. Then from equations (2), (3) it easily follows that

$$L^*(t,s) \geq L(t,s), \quad H^*(t,s) \leq H(t,s) \;\; \forall t \leq \bar{t}, \; \forall s \in [0,\omega], \tag{33}$$

hence, in particular,

$$\tilde{L}^*(\bar{t}) \geq \tilde{L}(\bar{t}), \quad \tilde{H}^*(\bar{t}) \leq \tilde{H}(\bar{t}).$$

From the continuity of $u$ and $u^*$ one easily obtains that (due to the jump of $L^*(t,0)$ at $t=\bar{t}$) for all sufficiently small $h \geq 0$

$$\tilde{L}^*(\bar{t}+h) \geq \tilde{L}(\bar{t}+h) + \alpha h, \quad \tilde{H}^*(\bar{t}+h) \leq \tilde{H}(\bar{t}+h) + o(h), \tag{34}$$

where $\alpha$ is a positive constant (depending on the jump $N_0^* - N_0$), and $o(h)/h \to 0$ when $h \to 0$.

Now we compare the solutions $\Delta$ and $\Delta^*$ of the adjoint equations (31) corresponding to the two scenarios (with (32) plugged into the respective equation). We have

$$\left(\frac{Y}{\tilde{L}}\right)^{1-\rho} = \left(\theta_L + \theta_H \left(\frac{\tilde{H}}{\tilde{L}}\right)^{\rho}\right)^{\frac{1-\rho}{\rho}}, \qquad \left(\frac{Y}{\tilde{H}}\right)^{1-\rho} = \left(\theta_H + \theta_L \left(\frac{\tilde{L}}{\tilde{H}}\right)^{\rho}\right)^{\frac{1-\rho}{\rho}}.$$

From (34) we obtain

$$\frac{\tilde{H}(\bar{t}+h)}{\tilde{L}(\bar{t}+h)} \geq \frac{\tilde{H}^*(\bar{t}+h)}{\tilde{L}^*(\bar{t}+h)} + \alpha_1 h, \qquad \frac{\tilde{L}(\bar{t}+h)}{\tilde{H}(\bar{t}+h)} \leq \frac{\tilde{L}^*(\bar{t}+h)}{\tilde{H}^*(\bar{t}+h)} - \alpha_1 h,$$

where $\alpha_1 > 0$ is an appropriate constant (depending on $\alpha$) and $h$ is sufficiently small. The above two formulas and the assumption that $\theta_L$ and $\theta_H$ are strictly positive imply that

$$\left(\frac{Y}{\tilde{L}}\right)^{1-\rho} \geq \left(\frac{Y^*}{\tilde{L}^*}\right)^{1-\rho} + \alpha_2 h, \qquad \left(\frac{Y}{\tilde{H}}\right)^{1-\rho} \leq \left(\frac{Y^*}{\tilde{H}^*}\right)^{1-\rho} - \alpha_2 h,$$

where the arguments $\bar{t}+h$ are skipped and $\alpha_2 > 0$ is another constant as before. The above inequalities imply that

$$f^*(\bar{t}+h, s) \geq f(\bar{t}+h, s) + \alpha_3 h.$$

Using (33) we obtain in the same way that

$$f^*(t,s) \geq f(t,s) \quad \text{for } t < \bar{t}, \;\; s \in [0,\omega]. \tag{35}$$

Then an elementary comparison (viability) argument implies (considering equation (31) along the characteristic lines staring at $(\bar{t}+h, \omega)$) that

$$\Delta^*(\bar{t}, \omega - h) > \Delta(\bar{t}, \omega - h) \tag{36}$$

for all sufficiently small $h > 0$. Having in mind (32) we obtain that if $u(\bar{t}, \omega - h) > 0$ then $u^*(\bar{t}, \omega - h) > u(\bar{t}, \omega - h)$ and the proposition is proved due to the continuity of $u$ and $u^*$. In the alternative case we fix $h$ so that (36) holds and consider $u(\bar{t} - \tau, \omega - h - \tau)$ for $\tau \in [0, \omega - h - s_0]$. Due to assumptions (i) and (ii) of the proposition there exists a last $\tau_0$ such that for $\tau \leq \tau_0$ we have $u(\bar{t} - \tau, \omega - h - \tau) = 0$, which implies $u^*(\bar{t} - \tau, \omega - h - \tau) = 0$ according to our assumption at the beginning of the proof. Then using (35) we obtain by the same comparison (viability) argument as above that $\Delta^*(\bar{t} - \tau_0, \omega - h - \tau_0) > \Delta(\bar{t} - \tau_0, \omega - h - \tau_0)$. Due to (32) this implies $u(\bar{t} - \tau_0, \omega - h - \tau_0) = 0 < u^*(\bar{t} - \tau_0, \omega - h - \tau_0)$ and we come again to a contradiction with our initial assumption. This completes the proof. Q.E.D.

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# References

[1] Barucci, E., Gozzi, F.: Technology adoption and accumulation in a vintage-capital model. Journal of Economics 74, 1–38 (2001)

[2] Boucekkine, R., de la Croix, D., Licandro, O.: Vintage human capital, demographic trends, and endogenous growth. Journal of Economic Theory 104, 340-375 (2002)

[3] Boucekkine, R., Ruiz-Tamarit, R.: Special functions for the study of economic dynamics: the case of the Lucas-Uzawa model. Discussion Paper 2004/84, CORE, Université Catholique de Louvain (2004).

[4] Brokate, M.: Pontryagin's principle for control problems in age-dependent population dynamics. J. Math. Biology 23, 75–101 (1985)

[5] Card, D., Lemieux Th.: Can falling supply explain the rising return to college for younger men? A cohort-based analysis. The Quarterly Journal of Economics, May 2001, 705-746 (2001)

[6] Christiaans, T.: Aging in a neoclassical theory of labor demand. Discussion Paper No. 112-03, University of Siegen (2003)

[7] Connelly, R., Gottschalk, P.: The effect of cohort composition on human capital accumulation across generations. Journal of Labor Economics 13, 155-176 (1995)

[8] Feichtinger, G., Hartl, R.F., Kort, P.M., Veliov, V.M.: Anticipation effects of technological progress on capital accumulation: a vintage capital approach. J. Econom. Theory 126, 143–164 (2006)

[9] Feichtinger, G., Tragler, G., Veliov, V.M.: Optimality conditions for age-structured control systems. J. Math. Anal. Appl. 288, 47–68 (2003)

[10] Feichtinger, G., Tsachev, Ts., Veliov, V.M.: Maximum principle for age and duration structured systems: a tool for optimal prevention and treatment of HIV. Mathematical Population Studies 11, 3–28. (2004)

[11] Feichtinger, G., Hartl, R.F., Kort, P.M., Veliov, V.M.: Environmental policy, the Porter Hypothesis and the composition of capital. Journal of Environmental Economics and Management 50, 434–446 (2005)

[12] Freeman, R.B.: The effect of demographic factors on age-earnings profiles. The Journal of Human Resources 14, 289–318 (1979)

[13] Fukuda, S.-I., Owen, R.F.: Firm-specific human capital, sunk costs and macroeconomic adjustment in Japan: who bears the burden. Working Paper (2004)

[14] Katz, L.F., Autor, D.H.: Changes in the wage structure and earnings inequality. In: Ashenfelter, O., Card, D. (Eds.) Handbook of Labor Economics, Vol. 3, pp 1463-1555. Elsevier Science (1999)

[15] Katz, L.F., Murphy, K.M.: Changes in relative wages, 1963-1987: Supply and Demand Factors. Quarterly Journal of Economics 107, 35–78 (1992)

[16] Kremer, M., Thomson, J.: Why isn't convergence instantaneous? Young workers, old workers, and gradual adjustment. Journal of Economic Growth 3, 5-28 (1998)

[17] Lam, D.: Population growth, age structure, age age-specific productivity. Does a uniform age distribution minimize lifetime wages? Journal of Population Ecnomics 2, 189–210 (1989)

[18] Lucas, R.E.: On the mechanics of economic development. Journal of Monetary Economics 22, 3–42 (1988).

[19] Murphy, K.M., Welch, F.: The structure of wages. The Quarterly Journal of Economics 107, 285–326 (1992)

[20] Pfeiffer, F., Reuß, K.: Age-dependent skill formation and returns to education: Simulation based evidende. IZA Discussion Paper No. 2882 (2007)

[21] Prskawetz, A., Veliov, V.M.: Age-specific dynamic labor demand and human capital investment. Journal of Economic Dynamics and Control 31, 3741–3777 (2007)

[22] Prskawetz, A., Fent T., Guest R.: Workforce Aging and Labor Productivity. The role of supply and demand for labor in the G7, In: Prskawetz, Bloom, Lutz (eds.) Population Aging, Human Capital Accumulation, and Productivity Growth, A supplement to Population and Development Review, Vol. 34, pp 298-323 Population Council, New York (2008)

[23] Rojas, J.A.: Life-cycle earnings, cohort size effects and social security: a quantitative exploration, Journal of Public Economics 89, 465-485 (2005)

[24] Stapleton, D.C., Young, D.J.: Educational attainment and cohort size. Journal of Labor Economics 6, 330–361 (1988)

[25] Webb, G.F.: Theory of nonlinear age-dependent population dynamics. Marcel Dekker, New York (1985)

[26] Weiss, Y.: The determination of life cycle earnings: a survey. In: Ashenfelter, O., Layard, R. (eds.) Handbook of Labour Economics, vol.1, pp. 603-640. Elsevier, Amsterdam (1986)

[27] Welch, F.: Effects of cohort size on earnings: the baby boom babies' financial bust. Journal of Political Economy 87, 65–97 (1979)

[28] United Nations: World population prospects: The 2004 revision. United Nations, New York (2004)

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# The demand for older workers

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## 1. Background and Objectives

All the advanced economies are experiencing rapid population ageing caused by the combination of an increase in longevity and a sharp drop in fertility rates. This is likely to lead to reduced economic growth and a rising burden of dependency. It will pose serious problems for the public finances through growing pressure for expenditure on pensions, health and social care. Unless participation rates rise markedly, labour force growth will fall in Europe and Japan (OECD 2006). Exits from the labour force will begin to outnumber entrants, imposing heavy costs of adjustment on employers.

Increasing labour force participation among older people has a vital role to play in coping with these challenges in at least three ways (OECD 2006):

(a) by boosting labour force growth and thus offsetting the negative impact of population ageing on economic growth
(b) by reducing pressure on the public finances through later retirement and increased tax and pension contributions
(c) by smoothing the pace at which employers will have to adjust the composition of their workforce.

Improved participation by older workers can be brought about by a variety of actions targeted at both the supply and demand sides of the labour market.

This paper, which examines issues related to the demand for older workers in Europe, is one of a set of three. The two other papers deal with the factors influencing the supply of older workers (Van Soest, 2008) and training and human capital investment in older workers (Jacobs 2008). Each paper aims to set out:

(a) the principal policy questions in the area
(b) current state of the art in terms of understanding the key issues
(c) the main gaps and challenges in knowledge
(d) the current situation of relevant research infrastructures and networks in Europe
(e) the improvements required in terms of new infrastructures, methodological innovations, data etc.

## 2. Policy Issues

### *Policy at EU level*

Perhaps reflecting the lack of evidence on the role of demand, or even the relatively buoyant state of Europe economies until recent times, many of the strategies to promote an active ageing agenda at European level have concentrated on the supply side of the labour market. This is quite evident from the main steps taken by the European Union and its Member States in this domain. Consider, for instance, the Commission's Communication 'Towards a Europe for All Ages - Promoting Prosperity and Intergenerational Solidarity' (Commission of the European Communities 1999), which is the first concerted effort to set the policy agenda needed to deal with demographic ageing in Europe. Under the suggestive title 'The challenges: Ageing process and labour supply' this document discusses the need to introduce active ageing policies as a means to secure high levels of labour supply in

European labour markets (1999: 8-11). Similarly, a later Commission Communication on 'Increasing the employment of older workers and delaying the exit from the labour market' (Commission of the European Communities 2004) states 'For the economy as a whole the increase in participation and employment rates of older workers are crucial for using the full potential of labour supply to sustain economic growth, tax revenues and social protection systems, including adequate pensions, in the face of expected reductions in the population of working age' (2004: 3).

An overwhelming concentration on supply-side measures is also evident in policies advocated by the European Commission to reach the targets set in the Stockholm and Barcelona Declarations (having 50% of all individuals aged between 55 and 64 in employment, and increasing the effective age of labour market exit by 5 years by 2010). These included:

- Providing incentives for workers to retire later and for employers to hire and keep older workers
    - Removal of incentives for, and forms of, early retirement schemes and development of gradual exit strategies which value as much as possible the human capital of the experienced workers, and which set incentives in negotiated occupational pension schemes to remain longer in work.
    - Greater awareness on ageing among employers to tackle age discrimination by promoting the benefits of an age diverse workforce to both individuals and firms.
    - Reconsideration of the weight of seniority elements as part of pay with a view to bringing pay more in line with productivity and performance.
    - Incentives in collective agreements to recruit older unemployed persons.
    - Further development of package deals in collective negotiations which give greater choice for the individual workers to a lifelong development of their employability and adaptability.
- Promoting access to training and investment in work ability
    - Fostering age-related adaptability action in SMEs, notably by pooling training support structures and developing exchange mechanisms with a view to optimally accommodating job opportunities and vacancies.
    - Increasing continuing training of older workers, notably low skilled ones, to develop their work potential to the highest level.
    - Developing, in cooperation with public authorities, active labour market policies, e.g. personalised approaches to meet individual needs.
- Fostering working conditions conducive to job retention
    - Increased efforts to offer adapted part-time or fixed-term work contracts.
    - Adaptation of the work load, improvement of working conditions and upgrading health and safety measures to the needs of older workers. This should include easier transitions to other occupations inside and outside the enterprise in line with older age (Commission of the European Communities 2004: 5, 14).

Finally, this is evident in the 2005-08 Broad Economic Policies Guidelines, which call on Member States to support active ageing, by promoting appropriate working conditions, improving (occupational) health status and introducing adequate

incentives to work and discouraging early retirement (Commission of the European Communities 2005: 27).

Despite the strong emphasis on the supply side, the European active ageing agenda has nonetheless still highlighted some demand-side issues that need to be tackled. Looking at the measures listed above as ways of attaining the Stockholm and Barcelona targets, we can identify three principal demand side areas where action has been called for:

(a) the need to tackle age discrimination in the labour market;
(b) the need to re-design salary practices so as to reduce the weight of seniority elements (thus reducing the labour costs of older workers), and
(c) the need to create incentives to recruit older unemployed persons.

Notwithstanding the references to these areas, the EU agenda seems to lack a full understanding of the role that demand factors have in promoting the participation of older people in the labour market and expanding active lives. For instance, no consideration has been given to the need to introduce incentives that encourage firms to retain older workers. Also, no particular consideration has been given to the possible conflicts emerging between the need to increase labour market flexibility on the one hand, and the need to introduce policies that facilitate employment retention of older workers on the other.

***Policy at National Level***

Member States have pursued a wider variety of objectives and used a range of demand-side strategies to implement them. Sometimes, as in the case of employment protection legislation, the effects can be contradictory or even perverse. The principal areas on which national policy has focussed include:

*Containing Labour Costs:* A key question in relation to the market for older workers is the extent to which their wage rates reflect productivity. If the labour costs of older workers rise faster than their productivity, employers will be slow to hire them, and to retain them beyond a certain age. It is rare for governments to try to alter wage-setting practices directly in order to favour older workers. A much more common approach is to introduce some form of wage subsidy designed to bring labour costs and productivity into better alignment. These schemes are often quite expensive and may involve substantial deadweight and displacement costs. In many cases, the magnitude of these problems has not been estimated (OECD 2006). The general evidence in relation to how productivity varies with age is reviewed in the next section

*Employment Protection Legislation:* This type of legislation can make it more costly to hire older workers, for example when it specifies longer notice periods or higher severance pay for older workers, sometimes through tenure-related provisions. It is generally found that older workers who lose their jobs face greater difficulties in securing re-employment than do younger workers. This has led some governments to introduce various types of penalty (such as higher tax or social security contributions) for firms that lay off older workers. This may, however, have a perverse effect by leading employers to lower their hiring rates of older workers.

*Improving the Flexibility of the Market:* The position of older workers can be improved by ensuring that the labour market functions more smoothly. This can be achieved, for instance, by improving the information flow between potential employers and potential employees. Older unemployed individuals need to be encouraged to seek jobs actively and effectively. Several countries are experimenting with employment programmes specifically focussed on older workers. For example, the UK's New Deal 50 Plus uses qualified and motivated advisors to assist older workers with job search and placement (Atkinson et al. 2003). General strategies aimed at improving occupational health and safety also facilitate increased participation. A number of countries have taken steps to ease the transition between full-time work and full-time retirement by providing subsidies to part-time work for a period and removing restrictions on workers who wished to access their pension benefits while continuing to work on a part-time basis.

*Combating Negative Perceptions by Employers and Age Discrimination:* In accordance with the EU Council Directive 2000/78/EC, which established a general framework for equal treatment in employment and occupation, EU countries have enacted legislation and regulations which prohibit discrimination on the basis of age. Some of these regulations exempt older workers (e.g. those over 65). In some cases, countries have gone further and introduced measures to combat stereotyping and improve employers' attitudes to older workers.

## 3. Major progress in understandings

### *Relevant theoretical explanations of the demand of older people in the labour market*

The demand for older workers can be analysed both in terms of the factors that influence job creation and job destruction in the labour market, the so called 'equilibrium models', and in terms of the decision factors that condition the hiring decisions of individual firms. Rather than trying to provide a comprehensive account of the various theoretical frameworks in the literature, we will focus on the most relevant contributions that can help us to analyse the demand for older people in the labour market.

Within the variety of macro-level explanations, we should highlight the importance of Hetze and Ochsen's (2005) attempt to incorporate the effects of the ageing of the labour force in unemployment. The authors start with the assumption that employers try to maximise revenues in the decision of matching a given vacancy with an old or a younger worker. These revenues are determined, on the one hand, by the productivity differential between young and older workers, and on the other by the "separation risk" for both age groups. Separation risk refers to the probability that younger workers will engage in job search behaviour and leave for alternative employment or that older workers will leave to go into retirement (Hetze and Ochsen 2005: 5).

The authors then state that demographic ageing affects both job creation and job destruction. If older workers are less productive than their younger counterparts, then demographic ageing will result in a decrease in the number of vacancies, as these

would reduce the company's revenues. However, if older employees are more productive than younger workers or are willing to stay for longer with firms, then more vacancies will be created. With regards to job destruction, this is ultimately influenced by the variation in the separation risk displayed by the older generation. If older workers display a low separation risk, job destruction will lower. If, on the other hand, the separation risk is high, job destruction will increase (Hetze and Ochsen 2005: 8).

The final tenet in Hetze and Ochsen's model is that the impact of demographic ageing on unemployment is the product of the different combinations between the contradictory forces mentioned above. In this context, the authors identify four possible situations:

a) whenever the separation risk for older workers increases and this is not compensated by increases in productivity, then unemployment will increase;
b) whenever the separation risk and the productivity of the older cohort is lower than that of the younger cohort, the effect on unemployment is ambiguous;
c) whenever the differential of the separation risk of older workers clearly outweighs the differential in productivity, job creation will increase and job destruction will decrease, thus reducing unemployment;
d) whenever older workers are more productive than their younger counterparts, but also display a higher separation risk, then both job creation and job destruction increase, the effect on unemployment being ambiguous (Hetze and Ochsen 2005: 8-9).

Within the theoretical approaches that try to predict the demand for older workers from the firm's perspective, the best known is probably Lazear's 'delayed compensation contracts' model (1979). In trying to explain the existence of a mandatory retirement requirement, Lazear argues that a work contract where the worker is paid less than the value of his/her marginal product at younger ages, and more at later ages, has advantages for both workers and employers. For workers this type of contract will increase their lifetime wealth. Employers, although they are forced to bear the higher fixed costs associated with delayed compensation, gain from improvements in performance and stronger employee commitment which are induced by the workers' fear of losing delayed compensation. Mandatory retirement is required as a way of terminating the contractual work, as the worker would not voluntarily retire in a context where the current wage is higher than his/her reservation wage (Lazear 1979: 1265).

In this context, firms tend to avoid hiring older workers, as this will reduce the possible benefits of delayed compensation. Not only that, this will lead companies, if they do decide to opt for older workers, to offer them a lower wage than that paid to younger workers (Lazear 1979: 1263-5, 1277; Daniel and Heywood 2007: 37-8). This approach is often justified by the observation that many firms may employ older workers, but they never hire them.

Another relevant explanation for firms' decision to hire older workers is put forward by Hutchens (1988), who highlights the role of training in reducing the incentive to hire older workers. Hutchens argues that firms which provide on-the-job training that is specific to their firm will bear most of its cost - which is fixed for every new hiring. In order to reduce these costs, firms will attempt to reduce employee turnover by

investing in lasting relationships. The implication of this is that companies will either favour younger workers in the recruitment process or, when applicants are equally qualified, offer reduced wages to older workers (1988: 89-90).

The theories of 'statistical discrimination' proposed by Phelps (1972) and Arrow (1973) are also relevant to the analysis of how the demand for older workers operates. These approaches focus on how evaluators predict the productivity of applicants in the recruitment process. They start from the underlying assumption that discrimination in the labour market does not necessarily arise from an employer's taste for discrimination[1]. Instead, discriminatory practices derive from the fact that it is difficult and costly to obtain accurate information about the likely differences in productivity between two prospective workers. It is hypothesised that, in order to avoid these costs, employers make recruitment decisions by using a rule of thumb, based on assumptions about the productivity of certain categories of worker, such as those in certain age, gender or racial groups. In this sense, discriminatory practices emerge as rational ways of maximising profits in hiring (Arrow 1973: 23-32; Baumle and Fosset 2005: 1259-60).

***What do we know so far?***

Looking at the theoretical frameworks discussed in the previous section, we can identify four areas of research that will be of importance to inform the design of adequate polices to increase the demand of older workers in the labour market:

(a) Effect of macro-economic conditions in labour demand
(b) The impact of age, productivity and wages in labour demand
(c) Discrimination against older people
(d) Labour market regulations: increase flexibility in recruitment vs. improving worker retention

The following sections will survey the available evidence on these topics.

*The Effect of Macro-economic Conditions*

As a recent 'Employment in Europe' report (2007) shows, in a large majority of EU member states, there has been a significant increase in the participation of people aged between 55 and 64 in the labour market (European Commission 2007: 66). This reflects not only demographic effects (see European Commission 2007: 107) but also a series of measures adopted by member states in line with targets set in the Stockholm and Barcelona Declarations. However, bearing in mind that these gains were achieved in a period of strong economic growth, it is important to know how fluctuations in the macro-economy affect the employment prospect of older

[1] In his seminal work on discrimination in the labour market, Becker (1957) assumes that employers have a preference for a certain category of worker - that is, a taste for discrimination. He further assumes that the utility of the employer is an increasing function of both profits and the number of workers from the favoured group. If the wages of workers from the favoured (F) and disfavoured (D) groups are the same, the employer will tend to hire more individuals from the favoured group. However, if the salaries of D are lower, then the higher the percentage of F the higher the costs, and therefore the profits will drop. In the longer run, this means that, in a competitive market, non-prejudiced employers, as they have lower costs, will drive prejudiced employers out of the market (see Johnes and Sapsford 1996: 12).

unemployed. A study conducted by Blanco and De la Rica (2002) addressed this issue and showed that the demand of old (as well as young) workers follows the general trend of the business cycle. However, their study also suggests that the older unemployed encounter greater difficulties than their younger counterparts in re-entering jobs even when the economy is growing (2002: 19).

*Age, productivity and wages*

In most countries, cross-sectional data on earnings by age show a hump shaped profile, especially for men (OECD 2006: 66). This profile may reflect the fact that the productivity of workers initially increases with their work experience but then flattens off or declines after a given age. However, in some countries earnings rise more steeply with age or show little tendency to decline in the older age groups (see Table 1 for a listing of those countries that observe this rising age-earning profile). This may reflect the increasing productivity of workers as they gain more work experience, but this rising wage with age may also be linked to other factors.

**Table 1: Evidence of seniority wages in OECD countries**

| **Country** | **Whether there is evidence of seniority wages?** |
|---|---|
| **Austria** | Wages for men after age 40 continue to rise steeply. |
| **Belgium** | Seniority wages common for non-manual workers. |
| **Finland** | Non-wage costs rise with age, e.g. for disability insurance. |
| **France** | Wages rise steeply with age. |
| **Italy** | Some evidence that seniority wages reduce retention of older workers. |
| **Japan** | Wages rise steeply with age. |
| **Korea** | Wages rise steeply with age. |
| **Luxembourg** | Wages rise steeply with age. |
| **Spain** | Seniority wages still important despite some decline. High non-wage costs for part-time work. |
| **Switzerland** | Both wages and non-wage costs rise steeply with age. |
| **United States** | Non-wage costs rise with age, e.g. for health insurance. |

*Source*: OECD (2006: 64, Table 3.3)

In some of these countries, these age-earning patterns reflect explicit seniority wage-setting arrangements, usually in the form of collective agreements. In Korea and Japan, seniority wages are a deeply rooted part of their national wage practices, and this means that setting a mandatory age of retirement lower than the official age is also a standard firm practice in these countries. Seniority wages are also present, albeit less prominently, in the wage-setting practices of other countries, notably Austria, Belgium, France, the Netherlands and Spain. In Spain, for instance, although seniority has been playing a less important role over the past few years, about 80% of collective agreements still include seniority wage clauses.

In some other countries non-wage costs relative to wage costs rise with age, and so the rise in total labour costs with age is steeper than in wage costs alone. In Finland and Switzerland (in the occupational scheme), for example, social security

contributions rise with the age of workers. In the United States, employer-provided benefits such as health insurance and defined-benefit pension plans may result in non-wage costs that increase significantly with age.

In many countries, pension claims of tenured civil servants are linked to seniority wages rather than the wage base over the entire employment spell (for example, in Germany and the United Kingdom). Thus, there is an incentive to maximise pension claims by pushing up pay with seniority.

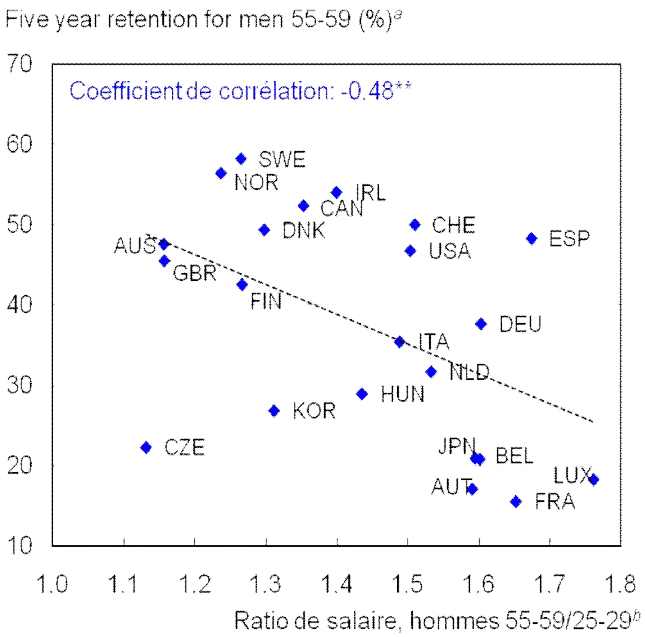
The evidence of a steep rise in wages with age raises questions regarding how productivity changes with wage. Some of the studies directly confront the linking of the pattern of productivity with the pattern for wages (for example Lazear and Moore (1984); Medoff and Abraham (1981); Oliviera, Cohn and Kiker (1989); Remery et al., (2001)) (see Table 1, Annex I). The majority of studies conclude that the patterns for wages and productivity differ with age, leading to a certain discrepancy in the link between wage and productivity at older ages.

A useful summary of the literature relating age to productivity is provided in Skirbekk (2003). This study reports that there is a range of evidence suggesting a decline in several aspects of physical and mental functionings from around the age of 50. This decline in abilities is often progressive and with substantial variation across individuals. The decline is uneven across different types of mental ability, with stronger reductions in "fluid" intelligence (such as reasoning power or speed of processing) than in "crystallised" intelligence (as reflected for instance in verbal and communications skills). The latter tends to remain relatively unchanged over much of the life cycle. Volkoff et al. (2000) argue that older workers can often rely on their professional experience to adapt and compensate for the decline in physical and mental ability, especially when assisted by suitable workplace adjustments. Warr (1993) takes the view that the age-related decline in job performance is small and states (p.238) that, based on analysis of a wide range of studies, "there is no significant difference between the job performance of older and younger workers".

Another form of evidence is drawn from a number of recent studies using matched employer-employee data. Crépon and Aubert (2003) found that the productivity of workers in France declines after the age of 55 while earnings continue to rise, although the difference in profiles is not statistically significant. Based on data for the manufacturing sector in the United States, Hellerstein and Neumark (2004) also found that workers aged 55 and over are less productive than workers in either the 35-54 age group age or younger age group (less than 35). At the same time, they found that the lower productivity of older workers is not matched by lower earnings.

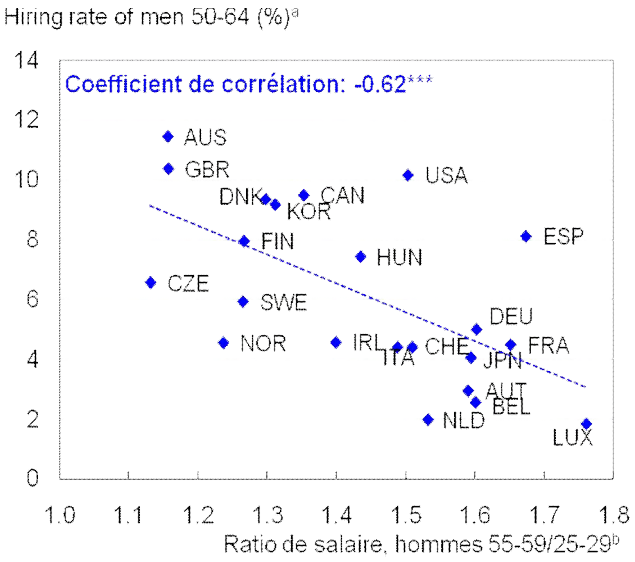
Overall, the evidence suggests that individual productivity does decline in some dimensions with age. However, this decline can be partly compensated for by experience, personal aids and suitable workplace adjustments. The French and US evidence at the firm level suggests that the productivity of workers declines after the age of 55 but this is not matched by a decline in their relative wages.

## Figure 1: Seniority wages and retention rate of older workers




*Source*: OECD (2006: 69)
*Notes*:
a). The retention rate refers to the estimated proportion of all employees in 1999 that were still with the same employer in 2004
b) The earnings data refer to full-time workers only for various years over the period 1998-2003.

## Figure 2: Seniority wages and hiring rate of older workers




*Source*: OECD (2006: 69)
a) The hiring rate refers to the ratio of employees with less than one year of tenure to all employees. The data refer to 2004.
b) The earnings data refer to full-time workers only for various years over the period 1998-2003.

Looking at the evidence on the impact of seniority wages on the employment of older workers, an OECD study shows that, insofar as older men are concerned, there is negative relation between the two variables. For instance, as can be seen from Figure 1, there is a negative relationship between the drop in retention rates that occurs for men aged 55-59 relative to men aged 45-49 and the wages of older men relative to those of younger men. Hiring rates of older workers are also negatively correlated with seniority wages (see Figure 2). Thus, all other things equal, employers are more likely to hire and retain older (male) workers in countries where wages rise less steeply with age (OECD 2006: 69).

Reviewing within-country studies, there is also evidence of a negative relationship between seniority wages and employment outcomes for older workers. Hirsch et al. (2000) reports that for the United States both the overall employment shares of older workers within narrowly defined occupations, as well as their share of all hiring. tends to be negatively associated with the wage premium on experience. Similarly, Aubert (2005) reports a negative correlation between the employment share of older workers and their wages relative to younger workers, especially after the age of 55, after controlling for the level of qualifications of workers. A similar negative correlation exists for hiring, except in the case of highly qualified workers.

### *Age discrimination in the labour market*

Looking at the literature on discrimination against older workers in the labour market, we can find two main strands. The first relates to assessing the extent of age discrimination in the labour market, the second addresses the impact of anti-discrimination policies.

Although there exists a range of data sources that could be used to measure discrimination against older workers in the labour market in Europe (see European Commission (2006)), the current evidence-base of studies on this issue is rather limited. For instance, there are relatively few examples of studies on the experience of age discrimination in employment. One such study is that of Duncan and Loretto (2004) who examined the experience of age discrimination in a UK financial services firm. Their study shows that, in a total of 17 per cent of employees who experienced mistreatment as a result of their age, workers aged 45 plus and those aged less than 25 where the ones to report the most negative experiences. They also found that women over 45 are in an even worse position than their male counterparts (2004: 110)

Another notable source of evidence is a special Eurobarometer survey on perceptions and attitudes towards discrimination in the European Union (European Commission (2007)). Amongst other things, the survey shows that almost half of the surveyed population feels that a candidate's age is, together with his/her appearance and the existence of a disability, one of the most important criteria that might put the candidate at a disadvantage when competing for a job against someone with the same qualifications (2007: 18). Not only that, the study shows that 78% of respondents feel that a person aged 50 plus is less likely to get a job, be accepted for training or be promoted, than someone aged under 50 (2007: 19).

Although relatively few in number, there are some laboratory[2] and field[3] experiments in relation to the employment prospects of older workers. These studies are more prevalent in the US[4] than Europe. One example is the laboratory experiment on age discrimination in job interviews, which was conducted by Busch and Konigstein (2001). The authors asked 174 German students to evaluate three hypothetical applicants with regards their working skills and adequate wage levels, and to decide whom to hire (2001: 4-5). Their study suggests that overall there were not many differences in how they evaluated job applicants, but negative age stereotypes emerged in the decision on who to hire (2001: 12-13). In addition to this, there is also, a set of field experiments conducted by Riach and Rich (2007a, 2007b and 2007c) in England, Spain and France, which found high levels of discrimination against older applicants. Curiously, whereas in Spain there was little variation in the levels of discrimination found (Riach and Rich 2007a: 7), in France and in England (especially) discrimination against older individuals is much higher in big metropolitan areas (Riach and Rich 2007b: 7; Riach and Rich 2007c: 13)

Meta-analyses conducted by Morgeson et al (2008) and Gordon and Arvey (2004) seem to suggest that the effective level of discrimination against older people in the labour market is much lower than it is commonly assumed (see Morgeson et al 2008: 230; Gordon and Arvey 2004: 485). Morgeson et al (2008) suggest that job-related information and job/applicant fit are more important factors in predicting hiring decisions than age. Not only that, Morgeson et al (2008) found that field experiments which involve experienced recruiters tend to show less discrimination than those conducted in the laboratory – which tend to use less experienced evaluators (2008: 230).

Another important insight into discrimination against older people in the labour market comes from employers themselves. Taylor and Walker's (1994) ground-breaking survey of 500 large employers (employing 500 people or more) showed that a sizable group of respondents had negative stereotypes of older workers, especially with regard to their openness to training and their ability to adapt to new technologies (1994: 581). A more recent comparative study, covering Greece, Spain, the Netherlands and the UK, confirmed this finding. However, there was variation in how employers from different countries perceived differences in productivity according to age – with UK employers being the most positive about the productivity of older workers, compared with younger employees, and Dutch employers been the least positive. The positive self-evaluation that older workers have of themselves is confirmed by the fact that 96% felt that workers above the normal retirement age could still make a valuable contribution to the firm (van Dalen 2006: 29).

[2] In laboratory experiments, participants are asked to play the role of interviewers/job selectors and evaluate randomly assigned job applications where qualifications are artificially minimised and the impact of the age variable is artificially maximised.

[3] Whereas laboratory experiments occur in a tightly controlled environment, field experiments are able to bring some elements of the standardised features of laboratory experiments to an environment that is closer to reality. Looking at the existing literature we can find two typical approaches in capturing discrimination in the labour market. On the one side, we have 'audit' (or 'situation') studies (Riach and Rich 2002: 481), where matched pairs of individuals, which differ only with regards to one particular characteristic (age, race, gender, etc.), are asked to attend job interviews or to apply over the phone. On the other side, we have correspondence studies (Riach and Rich 2002: 484), which involve sending pairs of written job applications that are closely matched in terms of individuals' qualifications and experience, but (again) differ only with regards to one particular characteristic.

[4] Morgeson et al (2008) identified 21 studies on discrimination against older people in employment interviews. Gordon and Arvey (2004) identified 32 studies on discrimination against older people in employment interviews and performance evaluations.

As mentioned earlier, the second stream in the literature on the discrimination of older workers concerns the labour market effectiveness of anti-discrimination legislation. Unfortunately, there are few European studies on this issue therefore we must rely on US based data for our review. Looking at the existing evidence we can find two contradictory views of the labour market effectiveness of anti-discrimination policies.

On the one hand, there are those who expect that the introduction of anti-discrimination laws would limit firms' ability to enforce delayed compensation mechanisms, such as mandatory retirement clauses (see Lazear 1979), leading to reduced incentives to hire older workers (see Adams 2004: 224). This view was corroborated by the study of Joanna Lahey (2006) who found that the ease with which age discrimination lawsuits could be initiated explains 5 to 8% of the difference in the number of weeks worked by individuals in states covered by both State and Federal anti-discrimination legislation (2006: 23). Moreover, Lahey found that older workers in states with anti-discrimination laws are more likely to retire by 0.3%, and less likely to be hired by 0.2% (2006: 24)[5]. This evidence, the author argues, points to the idea that the introduction of anti-discrimination laws will lead companies to avoid employing older workers as a means to avoid litigation (2006: 4).

An alternative view is that, rather than undermining them, anti-discrimination legislation actually strengthens delayed compensation contracts. These studies argue that, despite the elimination of mandatory retirement, firms are still left with sufficient instruments – i.e., various types of retirement incentives – that are effective in terminating the contractual relations with older workers. Furthermore, legislation outlawing age discrimination increases the cost of terminating an employee's contract, thus giving more credibility to delayed compensation contracts. This could even have the effect of reducing the firm's fixed costs of hiring (see Adams 204: 224). As evidence of this, Neumark and Stock (1997) found that the introduction of anti-discrimination laws increased employment by 0.067 for protected workers age 60 and over[6] (1997: 21). Adams (2004) also found employment gains for older workers protected by anti-discrimination, and losses for unprotected older workers (2004: 235)[7].

### *Labour market regulation, recruitment and retention*

Unfortunately, the evidence base on the effects of labour market regulation in older worker retention is scarce. For instance, the OECD (2006) study mentioned earlier showed that there is a non-statistically significant negative relation between EPL and the retention rate for men aged 55-59 – which would contradict the predictions of Lazear's delayed compensation model.

The evidence on the impact of labour market regulation on the employment prospects of older workers, on the other hand, is a bit more comprehensive. There is some

[5] Lahey also found that workers covered by anti-discrimination laws were less likely to be separated from their jobs, but this was not statistically significant (2006:22).

[6] Not only that, Neumark and Stock (1997) identified a steepening of age-earning profiles, which in itself provides evidence that these type of laws reinforce delayed compensation contracts (1997: 41).

[7] Curiously, Adams (2004) did not find evidence that anti-discrimination laws had a statistically significant effect on hiring and retirements (2004: 235-40).

evidence that higher levels of employment protection have a negative effect on the probabilities of older unemployed persons returning to work. A recent study by the OECD suggests that there is a statistically significant negative relation between employment protection (here measured through an Index of Employment Protection Legislation (EPL)) and the employment rate of people aged between 50 and 64, and between EPL and the hiring rate of men aged 50 to 64 (OECD 2006: 71-72).

Some studies at national level lend support to this finding. For instance, using matched individual/establishment data from the 1998 Workplace Employment Relations Survey (WERS), Daniel and Heywood (2007) found strong evidence that the existence of delayed compensation mechanisms, such as mandatory pensions, reduce the likelihood of companies hiring older workers (2007: 49). Also, using data from the Spanish Current Population Survey, Blanco and De la Rica (2002) found that older workers, because they have a longer contribution history, are entitled to longer unemployment benefits, but suffer from lower re-employment probabilities (2002: 14-20).

There is, however, some controversy as to what is the net effect of EPL on the employment rate of older workers. In addition to a negative impact on hiring, the OECD (2006) study mentioned earlier showed a statistically significant relation between the employment rate of people aged between 50 and 64 (OECD 2006: 71-72). Moreover, the study found that more dynamic labour markets (that is, labour markets with higher levels of job creation and job destruction) - and presumably, less regulated - tend to be more disadvantaging for older workers, as they tend to be more affected by job destruction (OECD 2006: 71-72). In contrast, Bassanini and Duval (2006) suggested that there was a positive relation between EPL and the employment rate of workers aged 55 to 64, which indicates that the negative impact that EPL can have on hiring might be substantially outweighed by a reduction in the dismissal of older workers (2006: 47-8).

## 4. Remaining gaps in knowledge

Reflecting on the previous sections we can identify a number of gaps in the existing evidence base on the factors that drive the demand of older workers in Europe:

a. With few exceptions, the general theoretical frameworks that try to explain demand in labour markets, because they assume homogeneity in labour supply, are not well equipped to deal with the impact of demographic ageing on labour demand. Furthermore, these frameworks tend to incorporate assumptions about the relation between age and productivity that are not grounded in the empirical evidence. In this sense, there needs to be an effort to **improve the theoretical models** that try identify the factors which influence labour market demand in general, and the demand for older workers in particular;
b. Although there is some evidence on the **extent of age discrimination** in the labour market, there is little research on its real impact in terms of older people's opportunities to enter employment and to be promoted. There is also little evidence of what has been **the impact of anti-discrimination measures**, taken both at the national and the EU-level, on the employment prospects of

older workers. This is an important gap to fill, given its usefulness for policy-makers and the possibility that such measures can have perverse effects;

c. The evidence base on the **impact of labour market regulation** on the employment prospects of older workers is scarce and somewhat contradictory. An area that requires particular attention concerns the analysis of the possible conflict between trying to improve overall labour market flexibility and the need to keep older workers in the labour force. Furthermore, it is important to identify the policy-linkages between different areas of public policy (taxation, pension regulations and employment protection, etc.) in this domain.
d. As outlined above, there is no unanimity in the literature on the **relationship between age and productivity**. Studies are needed which differentiate more clearly between the patterns exhibited by different types of worker (e.g. those with higher or lower levels of education) and between different types of tasks and occupations (e.g. those requiring speed rather than considered judgement).
e. We need to know more about the **factors influencing the retirement decision** and about the substantial differences which can arise between members of different occupational, income, educational and ethnic groups in this regard.
f. There is much less literature on the **position of older women** in the labour market than on older men. There are substantial differences between the genders in relation to a range of labour market factors (e.g. levels and trends in participation, influence of family responsibilities, extent of part-time work etc.) All of these have specific implications for the situation of women as they approach retirement.
g. Similarly, we know relatively little about the **long run income prospects** of those who take early retirement and how this varies across different groups in the population. This will be critical in determining how poverty rates among older people will develop over time.
h. Finally, despite the availability of large cross-national sources of information, there is little **internationally comparative research** on these topics, which would benefit from the cross-institutional variation that these sources would allow.

## 5. Current state of play of European research infrastructures and networks

As the previous sections have suggested, there is a good range of basic cross-sectional datasets which could provide relevant information on these topics. For example, EUROSTAT provides a series of cross-national databases (EU-SILC, European Labour Force Survey; MISSOC, OMC for pensions, etc.). These have not yet been fully exploited.

There is in addition an emerging set of longitudinal studies in the area of ageing such as the Survey of Health, Ageing and Retirement in Europe (SHARE), the English Longitudinal Study of Ageing (ELSA) or the (forthcoming) Irish Longitudinal Study on Ageing. These studies have three great strengths:

a) they are multi-disciplinary allowing better insights into the various domains of older people's lives
b) they are longitudinal, so allowing studies of process and permitting better causal inferences
c) they are designed to be internationally comparable both within Europe and with studies elsewhere in the world.

The principal networks doing research in this area of which we are aware are:

a) NETSPAR (Network for Studies on Ageing pensions and Retirement).
b) ASPEN Network (Active Social Policies European Network)
c) RECOWE (Reconciling Work and Welfare in Europe).

These bring together groups of high level economists and other social scientists with an interest in issues about employment and labour market regulation in Europe.

Also, the teams that are developing SHARE, ELSA and TILDA have strong interrelations and could provide a basis for developing research in this field.

## 6. Required research infrastructures, methodological innovations, data, networks etc., and consequences for research policy

The principal priorities for future research are in our view:

a) Continued and enhanced support for the emerging longitudinal studies and their international harmonisation
b) More investment in the matched worker/employer datasets along the lines of the 1990 Decennial Employer-Employee Dataset in the US, or 1998 Workplace Employment Relations Survey in the UK. Ideally, this would require a cross-national initiative, somewhat similar to the EU-SILC experience, which could provide comparable matched worker/employer data across different countries, economic sectors and labour markets.
c) Better data on employers' attitudes and behaviour in relation to recruitment of older workers
d) More resources to permit exploitation of both the cross-sectional and longitudinal data

## Annex I

### Table 2: Review of empirical studies on age and productivity

| Study | Group analysed | Findings |
|---|---|---|
| Waldman and Aviolo (1986) | Meta-analysis of 40 studies | No clear association between age and performance. Results vary and also depend on performance indicator: on averages, a positive correlation in the case of indicator type 1 and peer ratings, and negative in cases of indicator type 3 (supervisors' ratings). |
| McEvoy and Cascio (1989) | Meta-analysis of 96 studies | No clear association between age and performance (results vary in individual studies). This conclusion holds when a separate division of studies is made according to performance and type of work (professional vs. non-professional). |
| Bureau of Labour Statistics (1957) | Employees in large plants in men's footwear and household furniture industries | Decline in output per hour in older people, starting noticeably after about 45 years of age. |
| Kutscher and Walker (1960) | Office workers, USA | Very little differences in output per hour between age groups. |
| Walker (1964) | Mail sorters, USA | Very little differences in output per hour between age groups. |
| Stephan and Levin (1988) | Researchers within the physics, geology, physiology and biochemistry sectors | Negative association with age. |
| Oster and Hamermesh (1998) | Researchers in Economics | Negative association with age. |
| Miller (1999) | Artists, painters, musicians and writers | The peak ages are in the 30s and 40s. |
| Lazear and Moore (1984) | Self-employed and employees | Wage profile of employees is much steeper than for self-employed. |
| Oliviera, Cohn and Kiker (1989) | Self-employed in the USA (compared with employees) | Productivity increases strongly in younger people but declines in older people (parabolic). Earnings tend to stabilize in older people for employees in similar functions. |
| Medoff and Abraham (1980,, 1981) | White collar employees in a number of large American corporations | Seniority is either unrelated or negatively associated with performance evaluations. So wage growth with experience cannot be explained by growing productivity. |
| Flabbi and Ichino (2001) | Employees in a large Italian firm | Seniority is unrelated to performance evaluations. |
| Remery et al. (2001) | Dutch private and public companies/organizations | Companies expect increases in wage costs because of ageing of their workforce, but no increases in productivity |
| Gelderblom, de Koning and Kroes (2004) | Dutch private and public companies/ organizations | A large group of managers and HR managers do not see differences in the average productivity of those 55 and older compared to younger workers. |
| Gelderblom and de Koning (1996) | Civil servants in the Netherlands | Older workers have more problems with work pressure, but perform well on social skills |
| Haegeland and Klette (1999) | Manufacturing companies in Norway | Decline for those with more than 15 years experience (late 30s and over) |
| Hellerstein et al. (1999) | Manufacturing companies in US | Increase/decrease over life cycle according to model specification |

| Study | Group analysed | Findings |
|---|---|---|
| Ilmakunnas et al. (1999) | Manufacturing companies in Finland | 40 years old peak. Declining thereafter |
| Crépon et al. (2002) | Manufacturing and non-manufacturing companies in France | 25-34 year peak. Lowest for those over the age of 50. |
| Gelderblom and de Koning (2002a) | Manufacturing and non-manufacturing companies in the Netherlands | Productivity is rising until somewhere between 40-50 and declining afterwards. Productivity is relatively high compared to wages at middle ages. The younger and older have less favourable productivity-wage ratios. |
| Gelderblom, de Koning and Kroes (2004) | Manufacturing and non-manufacturing companies in the Netherlands | Productivity is rising until the age of around 50, after which a strong decline occurs. |

*Sources*: European Commission (2006:77-79), which is partly based on Gelderblom and Vos (1999) and Skirrbekk (2003).

**References**


- Adams, S. (2004) "Age discrimination legislation and the employment of older workers", *Labour Economics*, No. 11: 219–241
- Arrow, K. (1973) "The Theory of Discrimination" in O. Ashenfelter and A. Rees (eds.) *Discrimination in Labor Markets*, Princeton: Princeton University Press: 3-33.
- Arrow, K. (1998) "What Has Economics to Say about Racial Discrimination?", *The Journal of Economic Perspectives*, Vol. 12, No. 2: 91-100.
- Atkinson J, Evans C, Willison R, Lain D, van Gent M. (2003) *New Deal 50plus: Sustainability of Employment*, Report WAE142, Department for Work and Pensions,
- Aubert, P. (2005), "Les salaires des seniors sont-ils un obstacle à leur emploi?", *Les salaires en France*, INSEE, June.
- Baumle, A. and Fosset, M.(2005) "Statistical Discrimination in Employment: Its Practice, Conceptualization, and Implications for Public Policy", *American Behavioral Scientist*, No. 48: 1250-74
- Becker, G. (1957) *The economics of discrimination*. Chicago: University of Chicago Press.
- Bergmann, B (1974) "Occupational Segregation, Wages and Profits When Employers Discriminate by Race or Sex", *Eastern Economic Journal*, Vol. 1, No. 2: 103-110.
- Bergmann, B. (1971) "The Effect on White Incomes of Discrimination in Employment", *The Journal of Political Economy*, Vol. 79, No. 2: 294-313.
- Blanco, A. and De la Rica, S. (2002) "Unemployed older workers versus prime age workers: Differences in their re-employment determinants in Spain", Documentos de Trabajo Universidad del País Vasco. Departamento de Fundamentos del Análisis Económico II , Nº. 8.
- Blank, R., Dabady, M. Citro, C. (2004) *Measuring Racial Discrimination: panels on methods for assessing discrimination*, Washington, D.C.: National Academies Press,
- Büsch, V., Königstein, M. (2001) "Age Discrimination in Hiring Decisions: A Questionnaire Study", Conference Paper 2001, CEPII. Retrieved from www.cepii.fr/anglaisgraph/ communications/pdf/2001/enepri07080901/busch-konig.pdf
- Crépon, B. and P. Aubert (2003), "Productivité et salaire des travailleurs âgés", *Economie et Statistique*, No. 368: 157-185.
- Daniel, K. and Heywood, J. (2007) "The determinants of hiring older workers: UK evidence", *Labour Economics*, No. 14: 35–51
- Duncan, C., and Loretto, W. (2004) "Never the right age? Gender and age-based discrimination in employment", *Gender, Work, & Organization*, No. 11: 95-115.
- European Commission (2006) *European handbook on equality data*, Brussels: European Commission - Directorate-General for Employment, Social Affairs and Equal Opportunities.
- European Commission (2007) "Discrimination in the European Union", *SPECIAL EUROBAROMETER 263*, Brussels: European Commission

- Gelderblom, A. and G.J. Vos (1999). 'Age and Productivity.' R.M.Lindley (Ed.) *The Impact of Ageing in the Size, Structure and Behaviour of Active Age Population and Policy Implications for the Labour Market*. Coventry: Institute for Employment Research.
- Gordon, R. and Arvey, R. (2004) "Age Bias in Laboratory and Field Settings: A Meta-Analytic Investigation", *Journal of Applied Social Psychology*, Vol. 34, No. 3: 468-492.
- Heckman, J. and Siegelman, P. (1993) "The Urban Institute Audit Studies: Their Methods and Findings" In M. Fix and R. Struyk (eds.) *Clear and Convincing Evidence: Measurement of Discrimination in America*, Urban Institute.
- Hellerstein, J.K. and D. Neumark (2004), "Production Function and Wage Equation Estimation with Heterogeneous Labor: Evidence from a New Matched Employer-Employee Data Set", NBER Working Paper No. 10325, National Bureau of Economic Research, Cambridge, MA, February.
- Hetze, P. and Ochsen, C. (2005) "How Aging of the Labor Force Affects Equilibrium Unemployment", Thünen-Series of Applied Economic Theory Working Paper No. 57
- Hirsch, B.T., D.A. MacPherson and M.A. Hardy (2000), "Occupational Age Structure and Access for Older Workers", *Industrial and Labour Relations Review*, Vol. 53, No. 3: 401-418.
- Hutchens, R. (1988) "Do Job Opportunities Decline with Age?", *Industrial and Labor Relations Review*, Vol. 42, No. 1: 89-99
- Johnes, G. and Sapsford, D. (1996) "Some recent advances in the economic analysis of discrimination", *International Journal of Manpower*, Vol. 17 No. 1: 10-25.
- Lahey, J. (2006) "State age protection laws and the age discrimination in employment act", NBER Working Paper No. 12048.
- Lazear, E. (1979) "Why Is There Mandatory Retirement?", *Journal of Political Economy*, No. 87:1261- 1284.
- Lazear, E.P. and R.L. Moore (1984). 'Incentives, productivity and labour contracts.' *Quarterly Journal of Economics*, No. 99, pp. 275-96.
- Medoff, J.L. and K.G. Abraham (1981). 'Are those paid more really more productive? The case of experience.' *Journal of Human Resources*, Vol. 16, No. 2: 186-216.
- Morgeson, F., Reider, M., Campion, M., Bull, R. (2008) "Review of Research on Age Discrimination in the Employment Interview", *Journal of Business Psychology*, No. 22: 223-232.
- Myrdal, G. (1944) *An American Dilemma*, New York: Harper.
- Neumark, D., Stock, W. (1997/1999) "Age discrimination laws and labor market efficiency", *Journal of Political Economy*, No. 107, pp: 1081– 1125.
- OECD (2006) Live Longer, Work Longer Ageing and Employment Policies
- OECD (2006), Ageing and Employment Policies: Live Longer, Work Longer, Paris: OECD.
- Oliviera, M.M. de, E. Cohn and B.F. Kiker (1989). 'Tenure, earnings and productivity.' *Oxford Bulletin of Economics and Statistics*, pp. 1-4.
- Olson, P. (2007)"On the Contributions of Barbara Bergmann to Economics", *Review of Political Economy*, Vol. 19, No. 4, pp. 475-496.

- Phelps, E. (1972) "The Statistical Theory of Racism and Sexism", *The American Economic Review*, Vol. 62, No. 4: 659-661.
- Remery, C., K. Henkens, J. Schippers, J. van Doorne Huiskes and P. Ekamper (2001). "Organisaties, veroudering en management: een onderzoek onder werkgevers" (Organisations, ageing and management: employers' views), NIDI, Report No. 61.
- Riach, P. and Rich, J. (2002) "Field experiments of discrimination in the market place", *The Economic Journal*, No. 112, pp. 480–518.
- Riach, P. and Rich, J. (2007a) "An Experimental Investigation of Age Discrimination in the Spanish Labour Market", IZA Discussion Paper No. 2654, Bonn: IZA.
- Riach, P. and Rich, J. (2007b) "An Experimental Investigation of Age Discrimination in the English Labour Market", IZA Discussion Paper No. 3029, Bonn: IZA.
- Riach, P. and Rich, J. (2007c) "An Experimental Investigation of Age Discrimination in the French Labour Market", IZA Discussion Paper No. 2522, Bonn: IZA.
- Skirbekk, V. (2003), "Age and Individual Productivity: A Literature Survey", Max Planck Institute for Demographic Research Working Paper, WP 2003-028, Max-Planck Institute for Demographic Research, Rostock.
- Taylor, P. and Walker, A. (1994) "The Ageing Workforce: Employers' Attitudes Towards Older People", *Work, Employment and Society*, Vol.8, No. 4, pp. 569-591.
- Van Dalen, H., Henkens, K., Henderikse, W., Schippers, J. (2006) "Dealing with an ageing labour force: What do European employers expect and do?", NIDI, Report No. 73.
- Volkoff, S., A. Fr. Molinié and A. Jolivet (2000), "Efficaces à tout âge: vieillissement démographique et activités de travail", Dossier du Centre d'Études de l'Emploi, No. 16, France.
- Warr, P. "In What Circumstances Does Job Performance Vary With Age", *European Work and Organizational Psychologist*, Vol. 3, No. 3, pp. 237-249.

# An Experimental Investigation of Age Discrimination in Labour Markets

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**Abstract**

Carefully-matched pairs of written job applications were made to test for age discrimination in hiring. In England a twenty-one year-old and a thirty-nine year-old woman applied for jobs where a “new graduate” was sought; men aged twenty-seven and forty-seven, inquired about employment as waiters; women aged twenty-seven and forty-seven, inquired about employment in retail sales. The rate of net discrimination against the older graduate, and against the older waiters in their London inquiries, correspond to the highest rates ever recorded anywhere, by written tests, for racial discrimination. There was a statistically significant preference for the older applicant in retail sales. Tests in France and Spain for waiters found high rates of net discrimination.

"He looks old to be a waiter" (White Teeth)

## I. Introduction

The growing interest in field experiments, as a method of empirical investigation in economics, is demonstrated by the special issue of *The B.E. Journal of Economic Analysis and Policy (Advances)*, (2006, 6, issue 2) which is dedicated to field experiments. Field experiments constitute a way of generating data to measure discrimination that is akin for example to the approach used by researchers in the physical sciences, in particular, in medical science. The first field experiment of discrimination in employment, which used pairs of matched, written job applications, was undertaken in the 1960s by Jowell and Prescott-Clarke (1970). They developed the technique to investigate racial discrimination in employment in England. The first time this experimental method was applied to investigate sexual discrimination in employment was in Melbourne during the 1980s (Riach and Rich 1987). The measurement of discrimination by making matched, written job applications has been received with approbation in the academic journals, for example - in a survey of evidence on discrimination, Darity and Mason stated "This (correspondence testing) is impressive direct evidence of discrimination from a powerful test procedure" (Darity and Mason 1998, p. 81).

Although it originated almost forty years ago, there has been virtually no application of this technique to measuring the extent of age discrimination in employment. This is surprising, given the widespread contemporary concern about the economic implications of the ageing population in Western countries, and the frequent recommendation that the only viable solution to the consequent "pensions' crisis" is

an extended working life. For example the Organisation for Economic Co-operation and Development (OECD), referring to the United Kingdom - "… in 2050, for every person over the age of 65, there will be only 2.1 individuals of working age compared to 3.7 in 2003" (OECD 2004, p. 36). The projections for other OECD member countries are similar, for example, France and Spain are projected to face a dependency ratio of less than two working to one person over the age of 65 by 2005. The British Government's response to this impending demographic difficulty came in a Green Paper issued in 2002 by the Department of Work and Pensions; *Simplicity, security and choice: Working and saving for retirement.* Amongst other observations it included; "Increasing employment among older workers is *essential* if we are to address the pensions challenge. Working longer can dramatically reduce the rate at which people need to save for their retirement" (Department for Work and Pensions 2002, Cmd. 5677, p. 93 - emphasis added).

It is the case, though, that there is a significant challenge in applying the experimental technique to age discrimination; this is the obvious variation in human capital across the generations. The logic of this experimental technique, as innovated by Jowell and Prescott Clarke, is to design the test so as to control *strictly* for human capital components such as education, qualifications, skills and experience, and so that the *only* distinguishing feature of the two job applicants is the characteristic, such as race or sex, which is being tested. The influence of race or sex on hiring decisions is consequently isolated. In the case of age there must inevitably be a variation in the job experience of the different age groups, and therefore a difficulty in determining whether any employment preference is attributable to a profit-maximizing response to differential human capital or to prejudice. Bendick (1996 and 1999), attempted to deal

with this issue by having older applicants who had spent 25 years in some unrelated activity, such as child-raising, military service or public school teaching, which generated no relevant experience for the employment being tested. Petit (2007) applied to jobs in the French financial sector and, like Bendick *et al.*, dealt with this problem by having an older applicant with experience in an unrelated activity, for example in industry, insurance or real estate sectors (Petit 2007, p. 376, footnote 3). This is a highly artificial construct and leads to uncertainties; for instance, do employers rate experience between ages 40 and 50 as equivalent to experience between ages 25 and 35? Also it is not a realistic basis for policy development as virtually no older workers fit such a pattern.

In our paper "Field Experiments of Discrimination in the Market-Place" (Riach and Rich 2002) we recommended that instead of adapting job applicants to the technique, the technique should be adapted to the special case of older applicants. In other words, to accept that the *job experience* component of human capital does vary between different groups and have realistic candidates make applications, but to control for all other dimensions of human capital.

A frequent accusation against older applicants is that they are less mentally able/flexible and less physically active than their youthful competitors; "… numerous surveys and research conducted in the past 15 years point to negative employer perceptions vis-à-vis older workers with respect to their productivity, cost, work motivation, health, receptiveness towards training and ability to cope with technological and organisational change" (OECD 2004, p. 97; see also Purcell *et al*. 2003, pp. 3-4). However the objective scientific literature is to the contrary; "The

finding from more than 100 research investigations is that there is no significant difference between the job performance of older and younger workers" (Warr 1994, p. 309).

We decided to confront such ageist attitudes by presenting older applicants who were not more than forty-seven, who were engaged in strenuous physical activity, such as competitive squash and cycling, and who demonstrated mental flexibility by an up-to-date interest in computers and information technology. In other words we controlled for the older candidate's mental and physical capacities, but not for their length of experience. In which case, if a preference were found for younger applicants with twenty years less experience, it would indicate a very significant level of prejudice against older applicants. On the other hand, if we were to find a preference for the older workers in such circumstances it could be interpreted as an economically rational response to human capital superiority, rather than prejudice against youth. The OECD recognises that; "…age discrimination is neither overt nor easily measured" (OECD 2004, p. 98). This is a challenge which we now address; what follows is the first realistic attempt to measure age discrimination by using the experimental technique of forwarding matched, written applications.

**2. The experiment**

The intention was to have pairs of job applicants who were carefully-matched in all respects except in the experience which inevitably goes with age. An implication of this approach is that jobs with a career hierarchy were ruled out of the investigation. For instance, academics in their mid-twenties would be applying for different posts to those in their mid-forties: the former would be applying for post-doctoral fellowships

or lectureships, whilst the latter would be applying for Chairs or Deanships. This is not to say that age discrimination may not be alive and well in academia, or in law, or in the civil service, but instead that it cannot be investigated by the technique of paired mail applications. We have chosen occupations where it is realistic to expect that applications will come from candidates aged twenty years apart.

There are two techniques for applying this experimental method. The first is to *respond to advertized vacancies*, as innovated by Jowell and Prescott-Clarke in 1969, and surveyed by Riach and Rich (2002). The second is to conduct the investigation by *forwarding unsolicited job inquiries* to a group of employers in some occupation, as innovated by Fidell in 1970 and surveyed by Riach and Rich (2004b). The former procedure confronts the employer with simultaneous pairs of fictitious job applications at a time when he/she has initiated recruitment and they will be dealt with during the normal hiring process, but the application and observation rate, and therefore the duration of the study, is dependent on the state of the labor market. The latter procedure is more expedient; all that is required is an appropriate listing of employers in a particular occupation, and two mailings about a month apart, if the intention is to test matched pairs and if suspicion on the part of employers is to be allayed. This procedure is more appropriate in occupations where inquiries are customarily initiated from the supply side and in small business, so ensuring the inquiry is likely to be answered by the same person who normally takes hiring decisions. As inquiries must arrive at least a month apart there is some randomness in the extent to which they will coincide with a vacancy, therefore there can be less expectation of "equivalent treatment" (both candidates being offered interviews) than with the first procedure. Nevertheless, if in the first mailing fifty per cent of inquiries

go from candidate A and fifty per cent from candidate B, with reversal in the following month, this variation in timing will not bias the overall outcome of the experiment: i.e. there is control by age for the timing of application receipt.

We decided to apply both techniques in this study. In England we applied to advertized vacancies for new graduates in those positions where a "degree in general" was the prerequisite for employment, rather than any specific degree. Vacancies were obtained from the Saturday Guardian and from various web-sites (www.jobs.guardian.co.uk; www.topjobs.co.uk; www.monster.co.uk). Entry into the profession of Chartered Accountancy is by application to an authorised training firm, consequently such firms expect to receive, without advertisement, a steady flow of inquiries. We also had our new graduates apply to all such firms in England. One of our new graduates was female and aged twenty-one; the other was female and aged thirty-nine i.e. an individual euphemistically designated in Britain as a "mature age" graduate. The latter applicant had worked for eleven years as a secretary and spent five years in full-time child-rearing before entering university. She was divorced with a child of ten to indicate that pregnancy was likely to be a thing of the past.

We chose this area of employment because of its contemporary relevance; in 2002/03 there were 95,590 female students over thirty in English universities (20.4 percent of total students) and the universities actively recruit this age group (Higher Education Statistics Agency 2002/03, unpublished data). An additional reason for targeting a 39 year-old applicant was to explore the possibility of obtaining some experimental confirmation of the survey evidence which suggests that age discrimination can impact at a quite early age; e.g. "In a survey of over 1000 people the Chartered

Institute of Personnel and Development found that … 1 in 4 think that employers are not interested in employing people over age 40" (Third Age Employment Network 2003). In 1996 a survey of employers found evidence that age discrimination started at 42 (Penna Sanders and Sidney 2002).

In an experimental investigation of age discrimination, for the reasons discussed above, it is not possible strictly to alternate the résumés, as is done in race and sex experiments, but in all non age-related characteristics the résumés of "new graduates" were alternated. In half the applications the older applicant was a law graduate from X and in the other half she was an economics graduate from Y. We could not use the names of genuine educational institutions or employers in the résumés for two reasons. First there is the risk of detection if an employer were to make direct contact with a genuine company or university falsely cited in a résumé. Secondly an educational institution might take legal redress against a party falsely claiming to possess one of its awards. We decided to deal with this difficulty by inventing fictitious universities and employers. Just such an approach had been adopted in the International Labour Office's investigation of racial discrimination in the German labor market: fictitious schools and universities were invented (Goldberg *et al.* 1996). There are approximately one hundred universities in Britain and all but a handful have locational names; either of a city or a county. We therefore chose an English city and county which did not have universities, but which quite plausibly might, and used them in the résumés of our "new graduates". There was a flood of new universities in the decade prior to these tests. In 1992 twenty polytechnics became universities with names like De Montfort, South Bank, Liverpool John Moores and London Guildhall. Since then there has been a steady trickle of additions with Chichester, Southampton

Solent and Thames Valley amongst those acquiring universities. If counties such as Hertfordshire and Staffordshire have universities why might not Herefordshire and Shropshire? If towns like Loughborough, Bournemouth and Brighton have universities is it not conceivable that Ipswich and Salisbury have universities? We therefore believe that employers recruiting graduates would be unlikely to have a definitive knowledge of the current list of universities. In the case of current and former employers we simply specified their field of activity, such as merchant banking or chartered surveying. University careers officers and a Course Leader in Business Studies provided advice on the personal profiles used for the graduates' résumés, and their realism and efficacy is confirmed by the fact that we did obtain responses from very large firms and major recruitment agencies.

Cultural and sporting interests were chosen to be interchangeable because of the practice of reversing résumés. They were also deliberately chosen to suggest that the older applicant had no stereo-typical ageist traits; the interchangeable interests included classical and contemporary dance, playing squash and language classes.

We sent unsolicited inquiries about possible job openings for male waiters to four hundred and seventy hotels and restaurants throughout England (two hundred and twenty in London and two hundred and fifty across the rest of the country). One applicant was twenty-seven and the other was forty-seven. We chose this area of employment because it is one where supply-side inquiries are customary, and because it is an area of small business where any inquiry is likely to find its way to those who normally take the hiring decision.

It was not possible to perform any reversal of résumés in this case as, unlike our "new graduate" applicants, the education of waiters could not have been undertaken simultaneously. Both candidates had completed year eleven of school, but in the case of the older candidate the prevailing award in England was General Certificate of Education (GCE) at Ordinary (O) level, whereas in the case of the younger candidate it was General Certificate of Secondary Education (GCSE). Both candidates had included English and Mathematics in their awards. In this case we invented fictitious restaurant names for current employers. The efficacy of this tactic in particular, and the content of our résumés in general is confirmed by the receipt of positive responses from some of London's most expensive and fashionable restaurants. "Interests" were chosen to demonstrate the older applicant's physical fitness, and capacity to cope with modern technology. The "interests" included competitive squash and internet usage; also, computing had been studied at evening class. The résumés of waiters were prepared in conjunction with advice from the head waiter of a two-star restaurant in London. In any one posting half the inquiries went from the older applicant and half from the younger, with reversal in the following month. The résumés used for the waiters are included in the Appendix.

We used an identical procedure in making inquiries about possible employment in three hundred female clothing stores in London In this case one female applicant was twenty-seven and the other forty-seven; fictitious names were invented for the retail shops where they currently worked as assistant mangers. We chose to include this area of employment because it is one of small business, where the inquiry is likely to be dealt with by the person who normally takes hiring decisions. An additional reason is that there is anecdotal evidence in England that retail sales is an area where some

employers do deliberately target older workers. The large "do-it-yourself" retailer, B&Q, is noted for hiring older employees because of the benefit which their experience provides customers.

Once again, the relevant content of our résumé in general is confirmed by the receipt of positive responses from some of London's more expensive and fashionable retail shops and from major High Street chains. A former senior personnel manager of a major retail chain advised us on the résumés for this occupation. In this case the "Interests" chosen to demonstrate the older candidate's physical fitness and mental agility were competitive tennis, the internet and learning Italian. Computer usage had been pursued at evening class.

The three pairs of English résumés were also vetted by an experienced employment consultant who specialises in advising older job applicants. We applied by surface mail and cited both an email and postal address for responses. The postal addresses were in comparable socio-economic districts of central London, approximately one mile apart. We have always been very careful to retain documentation of our research, so we were careful to print off applications and replies, so hard copies could be filed. Positive responses via email or surface mail were dealt with promptly and courteously with a reply explaining that alternative employment had already been secured.

The one publication where the ethical considerations involved in this deceptive procedure are dealt with, and compared with research activity in psychology, sociology and laboratory-experimental economics, is Riach and Rich (2004a). The alternative, non-deceptive, techniques for measuring discrimination have encountered

difficulties. Surveys of attitudes towards target groups in the labor market are not likely to produce honest and accurate responses, as demonstrated by La Piere's classic study. In 1934 he travelled through the USA with a Chinese couple and gained admittance to all except one of 241 hotels and restaurants approached. In response to questionnaires sent six months later to the same establishments, over 90 per cent replied they would not accept Chinese guests. (La Piere 1934) The econometrician's application of regression analysis to published data to deduce discrimination, pioneered by Blinder (1973) and Oaxaca (1973) has been subject to considerable criticism, which revolves around the specification of the model and the choice of independent variables; see for example (Gunderson 1989) On the other hand, carefully-designed deceptive field experiments can provide an unequivocal measure of discrimination.

**3. The results**

The outcome of this experiment is set out in Table 1 in a format which follows McIntosh and Smith (1974, p. 13) and which has since been adopted in field experiments across Europe; e.g. Brown and Gay (1985); Bovenkerk (1992, pp. 26, 31) (see Riach and Rich 2002, pp. F486-F491). Column 4 shows the number of occasions when one or both applicants received a favorable response; by post, telephone, fax or email. This total is divided as follows: column 5 shows occasions when both received favorable responses (equal treatment); column 6 shows occasions when only the younger received a favorable response (discrimination against the older); and column 7 shows occasions when only the older received a favorable response (discrimination against the younger). Column 8 is net discrimination; that is 7 minus 6, so that it is positive when the older applicant encountered more discrimination than the younger

applicant. The statistical significance of any finding of net discrimination was determined by the application of the chi-square test. The data were categorised as accepted /rejected for two applicants in a 2*2 contingency table (Riach and Rich 2002, pp. F493 – F496). A comparison with British experimental results for race and sex discrimination is provided in Table 2. The rate of net discrimination against the older graduate applicant of 59.6 percent is one of the highest ever recorded. The highest net rate of discrimination *ever previously recorded* by the written experimental method was 66.7 percent against Antilleans in France in 1977 (Riach and Rich 2002, Table 4, p. F500). In view of the encouragement given by government for people to retrain, and by universities for mature-age women to enrol, this result is quite disturbing. Our older female graduate had an equivalent degree, no greater likelihood of pregnancy and one might have thought that her life experience would have enhanced her human capital and employability. On the contrary, we had one reply which explained "I wanted to be honest with you, our client is looking for recent graduates who are looking for their first job. You obviously have substantially more experience than this and being honest I feel that it would be a waste of your time to take your application any further. Sorry if this sounds harsh but we do believe in being honest with people". (The younger applicant received a positive response: information on the job, and a request to complete a maths test and a questionnaire).

We report, in Table 3, the results for the sub-set of graduates, whose applications were to employers who possessed the imprimatur of "Investors in People". The net rate of discrimination in the case of these employers was 46.2 percent, which was statistically significant at the 0.01 level. The *Home Page* of this organization states; "Investors in People Standard is a straightforward, proven framework for delivering business

improvement through people…" (Investors in People 2005). It also states on the page; *Recruitment and Selection Model-Any Questions?* "The Recruitment and Selection Model focuses specifically on good recruitment and selection practices, and how they impact on performance". Apparently some members of Investors in People believe that "good recruitment and selection practice" involves discarding applications from graduates because they have reached the age of 39.

The rate of net discrimination against the 47-year-old waiter in London of 68.2 per cent is the highest ever recorded anywhere by the written experimental method. Table 2 indicates that McIntosh and Smith (1974) recorded a net rate of 30.0 percent for West Indians and Jowell and Prescott-Clarke (1970) recorded a rate of 11.0 percent for West Indians and 50.0 percent for Indians. Outside London discrimination was at the much lower rate of 13.8 percent so that the net rate for England was 28.8 percent.

In the case of retail sales we found a preference for the older applicant, which was statistically significant at the 0.05 level.

**4. Interpretation**

Warr (1994) presents a classification of job activity in four categories, based on the relationship of performance to age. First are "age-impaired activities" in which there is a negative relationship between age and performance; "… basic capacities are exceeded to a greater extent for older people and experience cannot help. Tasks of that kind include continuous rapid information processing and some forms of strenuous physical activity." (Warr 1994, p. 314) "... complex tasks, requiring a large number or processing steps, are especially likely to be susceptible to cognitive slowing" (Warr

1994, p. 315). Second are "age-counteracted activities", in which there is no relationship between age and performance, because older people have strategies to compensate for any decline in information processing skills or in physical capacity. For example "…middle managers may learned to conserve their energy and time by operating through day-to- day tactics which reduce cognitive and affective load" (Warr 1994, p. 317). Third are "age-neutral activities", in which there is no relationship between age and performance, because the work is relatively undemanding and routine "...primary memory is apparently unaffected by age; older people are as able as their younger counterparts to hold in memory small amounts of information that are being used in uncomplicated cognitive activities" (Warr 1994, p. 317). Fourth are "age-enhanced activities" in which performance improves with age, because of the favorable impact of experience. Knowledge-based activity without time pressure comes within this category. For example; "… in a study of an American company's sales staff older employees were rated much more positively than younger ones in almost every respect" (Warr 1994, p. 316).

Warr's framework provides an explanation for age-related employment preferences which arise from age-related human capital differences. Becker and Arrow/Phelps have provided the economic bases for employment preferences which arise from discriminatory attitudes in the market place. Becker's (1971) theory proposes that customers, employers and/or current employees will sacrifice economic benefit, in order to indulge a "taste" for eschewing contact with some perceived pariah group. The Arrow/Phelps (1973/1972) hypothesis of "statistical discrimination" refers to the incomplete information, which employers have of the productivity and work characteristics of individual job applicants; this induces employers to resort to

generalisations about the employment characteristics of groups, as a screening device to minimise the cost of information acquisition in the hiring process.

In the case of "new graduates", where we found a very high rate of discrimination against the older job applicant, it is not realistic to explain it by attribution to Warr's first category; the older graduate is 39, and has just completed a degree in a rigorous discipline: economics or law. Also she engages in squash or contemporary dance, and learns Italian. It is difficult to credit that discrimination is "statistical" in the sense defined by Arrow (1973) and Phelps (1972). Both the "new graduate" women are in the fertile age range and, theoretically, equally prone to employment interruption, although the age of the older candidate's child might indicate she had done with planned child-bearing. The nature of this employment is that employee-customer contact is minimal to moderate, so it is unlikely that employers are being driven by any customer pressure; instead a clue might be found in the reply quoted above; delayed entry into higher education and experience of work being viewed as a *disadvantage*, as it might have imparted confidence, self-assurance and a degree of independence which could make life difficult for low-level managers, i.e. a variant of employer discrimination à la Becker (1971). Some confirmation of this hypothesis was found when graduates were interviewed about their experience of job search; "… some employers appear to have regarded mature graduates with suspicion, not only unsure about where they might fit into an organisation, but also wary of their motives for doing a degree and imputing character flaws in those who had not followed the "normal" (in fact middle-class) educational route from secondary school into higher education" (Purcell *et al*. 2003, p. 26).

Waiters clearly come into Warr's category three, as the work is relatively undemanding and routine; also recall that our older waiter plays competitive squash, so his physical capacity to do the job can hardly be in doubt. The contrasting finding between London and the rest of England rules out "statistical discrimination"; it is not realistic to hypothesise that any constituents of incomplete information vary geographically, in such a way as to activate this reaction. As long ago as 1933 George Orwell in *Down and Out in Paris and London*, (1940, pp. 68-69) recognized the strange symbiosis between waiter and diner. It certainly is an occupation with a critical interaction between employee and customer, *and* in an economic activity where repeat business is vital for commercial success. There is critical interaction, for instance, between nurse and patient, but few of us are repeat customers of hospitals. This might suggest particular insight in the casual aside quoted at the outset of this paper, which comes from the television adaptation of Zadie Smith's novel *White Teeth*, that is, customer prejudice à la Becker. Given these findings for waiters we decided to conduct some tests in France and Spain. The results are reported in Table 4 and indicate rates of net discrimination against the older waiter (France 58.1%, Spain 64.5%) comparable to those found for London.

In their econometric study, which used data from the Workplace Employment Relations Survey, Daniel and Heywood found "…strong evidence for the role of deferred compensation and internal labor markets as a negative predictor of hiring older workers. This fits the hypothesis that efficient life-time incentive structures require hiring younger workers and employing them when old, but not hiring older workers" (Daniel and Heywood 2007, p. 49). However these factors cannot explain our results for graduates and waiters. Waiters do not operate in internal labor markets,

nor do they benefit from deferred compensation. Our older graduate is 39, whereas Daniel and Heywood distinguish between those under 50, and those who are 50 or over. With more than twenty years until retirement our mature age graduate hardly fits the hypothesis that - "… the firm does not hire older workers because their shorter employment horizon means they are less well motivated by delayed compensation" (Daniel and Heywood 2007, p. 37).

The geographical variation between London and the rest of England is unprecedented in this type of experimental research. It may be partly explained by differential unemployment rates: for the period of this experiment (July-September 2004) the Labour Force Survey records a rate of 7.2 percent for men in London, in contrast to a rate of 4.4 percent for the rest of England (Labour Market Statistics 2005). When unemployment is high, and more applicants are searching, it facilitates the exercise of any discriminatory penchant which employers may have. Conversely when unemployment is low, and fewer applicants are searching, employers have less opportunity to discard applicants simply on the basis of some arbitrary characteristic such as race, sex or age. The higher rate for London may also be partly attributable to a greater devotion to pursuit of the fashionable "celebrity lifestyle" in the cosmopolitan capital, with its emphasis on the "youth culture", which reflects the younger age distribution of the London population. The proportion of the Inner London population aged 20-39 in 2001 was 41.3 percent; the proportion of the population in that age range for the rest of England was 27.5 percent (Census 2001).

Retail managers clearly come into Warr's category four and, significantly, it is sales staff whom he cites as his example of age–enhanced activity. Both our applicants had

managerial backgrounds, and this is the most commercially-responsible job tested, so we interpret the preference for the older applicant as reflecting a realisation by employers that this is an employment where the job experience component of human capital contributes significantly to performance, which may include customer satisfaction. We have here a rational response to age-related human capital differences, rather than discrimination.

**5. Policy: implications and recommendations**

We found net discrimination against a 39-year-old graduate of 59.6 per cent and against a 47-year-old waiter, in London, of 68.2 percent. In the 1960s Political and Economic Planning (PEP), recorded discrimination of 90.0 per cent against Indians and Afro-Carribeans (Daniel 1968). The finding of that level of racial discrimination, by PEP, gave rise to considerable concern at the time: not least in the House of Commons during the Committee Stage and the Second Reading of the Race Relations Bill in 1967/8. All three major parties (including the Conservatives, who are ideologically committed to *laissez faire*) referred, with obvious concern to PEP's findings: Quentin Hogg the Conservative member for St. Marylebone (later Lord Hailsham, the Lord Chancellor) said, during the Committee stage; "… a great deal has happened in the last year. There has been the first Report of the Race Relations Board. There has been the PEP Report on Racial Discrimination … I tell the right hon. Gentleman plainly that, originally I was very critical of fresh legislation on this subject so soon after the last. But I was immensely impressed by the quality of some of the documents to which I have referred" (Parliamentary Debates 15 November 1967). Subsequently during the Second Reading Debate he said; "I was convinced in the end by the evidence of the PEP report and the Street Report…that in the fields of

housing and employment there are circumstances in which the economic laws would operate in favor of discrimination and against human rights" (Parliamentary Debates 23 April 1968).

It was right and proper that the British nation's statesmen reacted so, and took legislative action to confront racial discrimination in 1968. It is not unreasonable to expect equivalent concern and reaction in 2007 in respect, not just of the elderly, but also of the "young seniors" (for example our waiters), and, in the case of the graduate, the middle-aged. They are more numerous and just as deserving of protection as the black community. The portents, however, are not good; the deadline for implementing a European Union Directive on age equality legislation, agreed in 2000, was December 2006; the British legislation only came into force in October 2006.

An abiding mantra of British governments for the past twenty-five years has been the need for a "flexible labor market". It is rarely defined, but it is *demand-side* flexibility which is always implied. One official definition is; "In a "flexible" labor market where employment is little regulated (in terms of pay, working hours, restrictions on dismissal etc.) the creation of low-paid, part-time, short-term or otherwise non-standard jobs is unconstrained, and there is a high level of job turnover, employers screen less intensively before hiring" (OECD 1992, p. 207).

In the Green Paper, *Simplicity, Security and Choice: Working and Saving for Retirement*, the current British government has shown great concern for the demographic structure of the labor force; for instance, it estimates that the ratio of those 65 plus to those 15-64, will rise from 24.4 percent in 2000 to 32.8 percent in

2025 and to 39.2 percent in 2050 (Department for Work and Pensions 2002, p. 16). As we saw in the Introduction, the Government considers it *essential* that employment rates of older workers rise to meet this demographic/pensions crisis. It follows that a government, which proselytises for demand-side labor market flexibility, and which wants to encourage people to work longer, has an obligation to ensure *supply-side* flexibility for older workers, so that they are not trapped in the unemployment pool, or in unsatisfactory or oppressive current employment.

The age discrimination legislation enacted in 2006 puts the burden of proof on the complainant; i.e. he/she must provide proof that the employer has committed a discriminatory act. Experimental research (e.g. McIntosh and Smith; Riach and Rich 1987, 2006) of the hiring process has repeatedly demonstrated the uninformative, and sometimes dishonest, nature of rejection letters. The pattern of dishonesty was repeated in this study. For example, in an application for a graduate position, the younger applicant was sent the following response on 11 November:

"Thank you for sending your CV to …. Can you call me to discuss …".

The older applicant was sent the following response on 19 November:

"I am writing to inform you that you have not been selected for a registration interview with … on this occasion. Unfortunately your skills and experience to date do not exactly match our client's requirements at this time".

On another occasion the older graduate was sent the following on 7 August:

"… I regret to advise you we have no vacancy for a trainee chartered accountant. We have now filled all our training places".

Whereas on 12 August the younger applicant was sent:

"Due to holiday commitments, we are unable to offer you an interview until early September. If this is of interest to you, please contact … to arrange an appointment".

It follows that, in most cases, a rejected applicant would not be aware that they had incurred discriminatory treatment and, even if they did suspect it, they would lack evidence to demonstrate, before a legal tribunal, a prima facie case of discrimination. This is acknowledged, *inter alia*, by the OECD; "… age discrimination legislation may not be very effective since it is often easier to prove discrimination in dismissal than hiring" (OECD 2004, p. 99). It was also an important conclusion of Adams in his investigation of the impact of state age discrimination legislation in the USA. Using interstate data from as far back as the 1960s he concluded - "One thing is clear, however. There is no evidence that suggests there are positive effects for protected workers. The stock of older workers that are new hires did not change" (Adams 2004, p. 237). It follows that this is a particularly serious problem for policy to address, especially in view of the rates of discrimination detected in our experiment for people as young as 39 and 47. Nevertheless, as noted above, the British age discrimination legislation of 2006 puts the onus on a rejected job applicant to prove facts from which the Employment Tribunal could conclude that the respondent has discriminated.

If age discrimination in hiring is to be tackled effectively a new approach is required. We recommend that, to strengthen the effectiveness of age discrimination legislation, in respect of recruitment, any equal opportunity, or human rights, commission should be charged to play an *active, investigative* role in the recruitment process; that is, it should have power to conduct random audits of hiring and personnel practices. If employers were required to keep all records of job applications for a period of twelve

months, and obliged to justify decisions on short-listing for interview and final choice of candidate, in the event of random audit, it would create pressure for scrupulousness in the hiring decision. An appropriate analogy can be drawn here with the capital market. Public corporations have various duties with respect to reporting to shareholders, potential shareholders and the business community at large. They are also subject to independent financial audit, and they are usually required to satisfy an independent commission about various aspects of their financial activities. In effect, capitalist economies provide a range of regulations and checks to protect the owners of financial capital against unscrupulous practices and guard against the waste of this resource. Therefore it seems entirely appropriate that similar protection be afforded the owners of human capital, and that steps be taken to prevent it being wasted through employers using screening devices, such as race, sex or age, for purposes unrelated to job performance. Barbara Bergmann has also advocated a similar policy (see Bergmann 1986, p. 158).

A complementary recommendation is that the approach to combating age discrimination in recruitment should be one of affirmative action. Affirmative action inevitably invokes fierce controversy and opposition from the privileged group – usually white, middle-class, “prime-age”, protestant men.

In an investigative, or audit strategy, we recommend that employers should be required to justify why *appropriately-qualified* post-40/post-50/post-60 applicants have not been appointed. If the proportion of post/40/50/60 *appointments* is less than (say) 66 percent of the proportion of appropriately-qualified post40/50/60 *applications* then the employer should be required to review personnel policies and an auditor

would be involved in future selection procedures until significant improvement occurred. In other words we are recommending a form of affirmative action for the middle-aged and elderly. As Bergmann has explained - “The selection process often does have important subjective elements, allowing plenty of leeway for making mistakes as well as for decision-makers attitudes about race and gender to influence outcomes. Thus, it is wrong to assume that the candidate chosen in the absence of affirmative action is always or almost always better than all those sent away” (Bergmann 1986, p. 104).

Age-based affirmative action would not incur some of the opposition traditionally directed at race or sex-based affirmative action. We are only recommending that older applicants be given proportionate treatment in *jobs which they have already been doing*, or perhaps, at most, one step up in the hierarchy. The charge that they “only got the job because of their age” could not hold up: they have already demonstrated they have done the job. The other side of this coin is that the aged will not react, as some blacks and females do, in opposing affirmative action, because of their concern that it suggests they did not get the job on their merits. In this case their “merits” have previously passed muster.

Another significant distinction in respect of age-based affirmative action is that, whereas whites never become black, and only rarely do males become female, the young *do* become old. In other words we should expect lesser hostility from the “majority” group, as in this case they stand to benefit in their turn. Moreover in the current demographic environment the alternative to ensuring a fair employment deal for “older” workers are increased taxes to finance the growing pension bill.

**Table 1: Results for the Age Discrimination Tests**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| **Occupation** | **Location of test** | **Neither invited** | **Usable tests** | **Equal treatment** | **Discrimination against older** | **Discrimination against younger** | **Net Discrimination[a]** |
| **Graduate** | | | | | | | |
| Total (number) | | | | | | | |
| Percent | England | 373 | 47 | 15 | 30 | 2 | 28 |
| | | | 100 | 31.9 | 63.8 | 4.3 | 59.6*** |
| **Retail Manager** | | | | | | | |
| Total (number) | London | 273 | 27 | 3 | 8 | 16 | -8 |
| Percent | | | 100 | 11.1 | 29.6 | 59.3 | -29.6* |
| **Waiter** | | | | | | | |
| Total (number) | England | 390 | 80 | 11 | 46 | 23 | 23 |
| Percent | | | 100 | 13.8 | 57.5 | 28.8 | 28.8*** |
| Total London (number) | London | | 22 | 3 | 17 | 2 | 15 |
| Percent | | | 100 | 13.6 | 77.3 | 9.1 | 68.2*** |
| Total Rest of England (number) | | | 58 | 8 | 29 | 21 | 8 |
| Percent | | | 100 | 13.7 | 50 | 36.2 | 13.8 |

Note 1: Chi-squared tests were conducted on the response rates and the results are indicated in column 8 - * significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level.

a. A negative value indicates discrimination against the younger applicant.

**Table 2: Results for the UK Sex and Race Discrimination Tests**

| Occupation | Study | Location of test | Test on basis of | Net Discrimination percent |
|---|---|---|---|---|
| **Chartered accountant** | Riach and Rich (2006) | England | Sex | -20.0*[a] |
| **Computer analyst programmer** | Riach and Rich (2006) | London and South East | Sex | -35.3**[a] |
| **Engineer** | Riach and Rich (2006) | London, South, South-East, Home Counties | Sex | 23.1* |
| **Secretary** | Riach and Rich (2006) | London | Sex | -43.1***[a] |
| **Accountant, Electronics Engineer, Sales representative, Secretary** | Jowell and Prescott-Clarke (1970) | England | Race<br>Asian<br>West Indian | 50.0***<br>11.0 |
| **Clerk, Sales Representative, Secretary, Shop assistant** | Hubbuck and Carter (1980) | Nottingham | Race<br>Asian<br>West Indian | 42.0***<br>43.0*** |
| **Accountant, Clerical, Management Trainee, Salesman, Secretary** | McIntosh and Smith (1974) | Birmingham<br>London | Race<br>Asian/West Indian | 30.0*** |

Note 1: Chi-squared tests were conducted on the response rates and the results are indicated for net discrimination:
* significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level.

a. A negative value indicates discrimination against the male applicant.

**Table 3: Results for the Age Discrimination Tests for Graduates, for Firms Noted as "Investors in People"**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| **Occupation** | **Location of test** | **Usable tests** | **Equal treatment** | **Discrimination against older** | **Discrimination against younger** | **Net Discrimination** |
| **Graduate** | | | | | | |
| Total (number) | England | 13 | 7 | 6 | 0 | 6 |
| Percent | | 100 | 53.9 | 46.2 | 0.0 | 46.2** |

Note 1: Chi-squared tests were conducted on the response rates and the results are indicated in column 8:
* significant at the 0.05 level; ** significant at the 0.01 level

**Table 4: Results for the French and Spanish Age Discrimination Tests**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| **Occupation** | **Location of test** | **Neither invited** | **Usable tests** | **Equal treatment** | **Discrimination against older** | **Discrimination against younger** | **Net Discrimination** |
| **Waiter** | | | | | | | |
| Total (number) | France | | 31 | 1 | 24 | 6 | 18 |
| Percent | | | 100 | 3.2 | 77.4 | 19.4 | 58.1*** |
| Total Paris (number) | Paris | | 6 | 0 | 6 | 0 | 6*** |
| Percent | | | 100 | 0 | 100 | 0 | 100 |
| Total Rest of France (number) | Rest of | | 25 | 1 | 18 | 6 | 12*** |
| Percent | France | | 100 | 4.0 | 72.0 | 24.0 | 48.0 |
| **Waiter** | | | | | | | |
| Total (number) | Spain | 309 | 31 | 5 | 23 | 3 | 20 |
| Percent | | | 100 | 16.1 | 74.2 | 9.7 | 64.5*** |
| Total 4 Cities (number) | Barcelona | | 15 | 3 | 11 | 1 | 10 |
| Percent | Madrid | | 100 | 20.0 | 73.3 | 6.7 | 66.7*** |
| | Seville | | | | | | |
| | Valencia | | | | | | |

Note 1: Chi-squared tests were conducted on the response rates and the results are indicated in column 8 - * significant at the 0.05 level; ** significant at the 0.01 level; *** significant at the 0.001 level.

## Appendix
## Two Résumés Used in Job Applications for Waiter

### Résumé A

**Personal Profile of …**

**Personal details**

**Born** 13-4-1977

**email**

**Qualifications**

GCSE - 6 Subjects two of which were English and Mathematics
NVQ3 in Hospitality Supervision
NVQ2 in Food and Drink Services
'Computer Usage and Fine Wines of the World' studied in my course at College

**Employment**

**2001 – present:** Senior Waiter at Restaurante Venezia in Tunbridge Wells.

**1997- 2000:** Waiter at a restaurant in Brighton, which I moved to in order to gain a more responsible post, and to have experience of serving foreign food and fine wine.

**1994 -1997:** My first job was at a hotel in Brighton, where I initially served breakfast and afternoon tea, but was soon promoted to serving lunch and dinner.

**Sporting and cultural interests**

Mountain-biking and films.

RÉSUMÉ B

RÉSUMÉ OF …….

ADDRESS

EMAIL

AGE 47

EDUCATION

5 “O” levels (including English and Maths)
Evening classes at College - including food service, wine appreciation, restaurant management and computer skills.
NVQ2 in Food and Drink Services and NVQ3 in Restaurant Supervision.

EXPERIENCE

After leaving school I had a variety of jobs such as coffee shop server and barman. I became a waiter in 1988 and since then have had a variety of jobs in hotels and restaurants, serving English, French, Italian and Spanish food. I began in hotels in Torquay, Bath and Burford. My duties included, preparing the dining room and serving breakfast, lunch and dinner. I also helped with room service. Subsequently I moved to more senior and responsible jobs in restaurants in London, Oxford and Stratford-upon-Avon, serving food and wine. For the last three years I have been employed at “Claudettes” in Guilford as Deputy Head Waiter.

INTERESTS

I play competitive Squash and I enjoy restoring classic motor cycles. Also I enjoy using the internet.

## References

Adams, Scott J. (2004). 'Age Discrimination Legislation and the Employment of Older Workers', *Labour Economics*, Vol. 11, No.2, pp. 219-241.

*The B.E. Journal of Economic Analysis and Policy*, (2006), Vol. 6, Issue 2. www.bepress.com/bejeap/advances/6,issue2

Arrow, Kenneth (1973). 'The Theory of Discrimination, in Ashenfelter, Orley and Rees, Albert (eds.), *Discrimination in Labor Markets*, Princeton University Press, Princeton, pp. 3-33.

Becker, Gary (1971). *The Economics of Discrimination*, 2nd edition. University of Chicago Press, Chicago.

Bendick Jnr. Mark, Jackson, Charles and Romero, J. H. (1996). 'Employment Discrimination Against Older Workers: An Experimental Study of Hiring Practices', *Journal of Aging and Social Policy*, Vol. 8, No. 4, pp. 25-46.

Bendick Jnr. Mark, Brown, Lauren and Wall, Kennington (1999). 'No Foot in the Door: An Experimental Study of Employment Discrimination Against Older Workers', *Journal of Aging and Social Policy*, Vol. 10, No. 4, pp. 5-23.

Bergmann, Barbara (1986). *The Economic Emergence of Women*. Basic Books, New York.

Blinder, Alan (1973). 'Wage Discrimination: Reduced Form and Structural Estimates', *Journal of Human Resources,* Vol. 8, pp. 436-455.

Bovenkerk, Frank (1992). *Testing Discrimination in Natural Experiments: A Manual for International Comparative Research on Discrimination on the Grounds of 'Race' and Ethnic Origin*. International Labour Office, Geneva.

Brown, Colin and Gay, Pat (1985). *Racial Discrimination 17 Years After the Act*. Policy Studies Institute, London.

Census 2001. http://www.statistics.gov.uk/census2001/

Daniel, Kirsten and Heywood, John S. (2007). 'The Determinants of Hiring Older Workers: UK Evidence', *Labour Economics,* Vol.14, No. 1, pp. 35-51.

Daniel, W. W. (1968). *Racial Discrimination in England.* Penguin Books, England.

Darity Jr., William A. and Mason, Patrick L. (1998). 'Evidence on Discrimination: Codes of Color, Codes of Gender', *Journal of Economic Perspectives*, Vol. 12, No. 2, pp. 63-90.

Department for Work and Pensions (2002). *Simplicity, Security and Choice: Working and Saving for Retirement*. HMSO, London.

Fidell, L. S. (1970). 'Empirical Verification of Sex Discrimination in Hiring Practices in Psychology', *American Psychologist*', Vol. 25, December, pp. 1094-98.

Goldberg, Andreas, Mourinho, Dora and Kulke, Ursula (1996). *Labour Market Discrimination Against Foreign Workers in Germany*. International Migration Papers 7. International Labour Office, Geneva.

Gunderson, Morley (1989). 'Male-Female Wage Differentials and Policy Responses', *Journal of Economic Literature*, Vol. 27, pp. 46-72.

Higher Education Statistics (2002/03). *Statistics on Students in Higher Education in the United Kingdom*. Unpublished data. Higher Education Statistics Agency (HESA), Cheltenham, UK.

Hubbuck, Jim and Carter, Simon (1980). *Half a Chance? A Report on Job Discrimination against Young Blacks in Nottingham*. Commission for Racial Equality, London.

Investors in People. 2005. http://www.iipuk.co.uk

Jowell, Roger and Prescott-Clarke, Patricia (1970). 'Racial Discrimination and White-Collar Workers in Britain', *Race*, Vol. 11, No. 4, pp. 397-417.

La Piere, Richard (1934). 'Attitudes vs Actions', *Social Forces*, Vol. 13, No. 2, pp. 230-237.

Labour Market Statistics (2005). http://www.statistics.gov.uk/

McIntosh, Neil and Smith, David (1974). 'The Extent of Racial Discrimination', *Political and Economic Planning Broadsheet no.547*, Political and Economic Planning, London.

Oaxaca, Ronald (1973). 'Male-Female Wage Differentials in Urban Labor Markets', *International Economic Review*, Vol. 14, No. 3, pp. 693-703.

OECD (2003). *Ageing and Employment Policies, Spain*. OECD, Paris.

OECD (2004). *Ageing and Employment Policy, United Kingdom*. Paris, OECD.

OECD (2005). *Ageing and Employment Policy, France*, Paris, OECD.

OECD (1992). *The Job Study, Part 11 – The Adjustment Potential of the Labour Market*. OECD, Paris.

Orwell, George (1940). *Down and Out in Paris and London*. Penguin, Harmondsworth, UK.

Parliamentary Debates (1968). Volume 763, column number 78, 23 April. HMSO, London.

Parliamentary Debates (1967). Volume 754, column number 452, 15 November. HMSO, London.

Penna Sanders and Sidney (2002). 'Generation Flex to the Rescue?' http://www.management-issues.com.

Petit, Pascale (2007). 'The Effects of Age and Family Constraints on Gender Hiring Discrimination: A Field Experiment in the French Financial Sector', *Labour Economics*, Vol. 14, 371-391.

Phelps, Edmund (1972). 'The Statistical Theory of Racism and Sexism', *American Economic Review*, Vol. 62, No. 4, pp. 659-661.

Purcell, Kate, Wilton, Nick and Elias, Peter (2003). *Older and Wiser? Age and Experience in the Graduate Labour Market. Researching Graduate Careers Seven Years On.* Research paper no. 2. Warwick University, Warwick Institute for Employment Research.

Riach, Peter A. and Rich, Judith (2004a). 'Deceptive Field Experiments of Discrimination: Are They Ethical?', *KYKLOS*, Vol. 57, Issue 3, pp. 457-470.

Riach, Peter A. and Rich, Judith (2004b). 'Fishing for Discrimination', *Review of Social Economy*, Vol. 61, No. 4, pp. 465-486.

Riach, Peter A. and Rich, Judith (2002). 'Field Experiments of Discrimination in the Market Place', *Economic Journal*, Vol. 112, No. 483, pp. F480-F518.

Riach, Peter A. and Rich, Judith (1987). 'Testing for Sexual Discrimination in the Labour Market', *Australian Economic Papers*, Vol. 26, No. , pp. 165 – 178.

Smith, Zadie (2000). *White Teeth*. Hamish Hamilton, London.

Third Age Employment Network (2003). *Experience of Age Discrimination: The Evidence*. February, http://www.taen.org.uk

Warr, P. (1994). 'Age and Job Performance', In: Snel, Jan and Cremer, Roel (eds.), *Work and Aging: A European Perspective*, Taylor and Francis, London, pp. 309-322.