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POLICIES TO CREATE AND DESTROY HUMAN CAPITAL IN EUROPE

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ABSTRACT

Trends in skill bias and greater turbulence in modern labor markets put wages and employment prospects of unskilled workers under pressure. Weak incentives to utilize and maintain skills over the life-cycle become manifest with the ageing of the population. Policies to promote human capital formation reduce welfare state dependency among the unskilled and offset inefficiencies in human capital formation. Skill formation features strong dynamic complementarities over the life-cycle. Investments in the human capital of children have higher returns than investments in the human capital of older workers. There is no trade-off between equity and efficiency at early ages of human development but there is a substantial trade-off at later ages. Later remediation of skill deficits acquired in early years often does not meet the cost-benefit criterion. Positive returns to active labor market and training policies are doubtful. Skill formation is impaired when the returns to skill formation are low due to low skill use and insufficient skill maintenance later on in life. High marginal tax rates and generous benefit systems reduce labor force participation rates and hours worked and thereby lower the utilization rate of human capital. Tax-benefit systems redistribute resources from outsiders to insiders in labor markets, which can be both distortionary and inequitable. Actuarially fairer early retirement and pension schemes reduce the incentives to retire early and strengthen incentives for human capital investment by increasing the time-horizon over which returns to human capital are harvested.

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1 Introduction

The labor market prospects of unskilled workers are jeopardized by skill-biased technical changes and the globalization of the world's production activities (see, e.g., Katz and Autor, 1999). Moreover, some argue that the position of unskilled workers has become more vulnerable in recent, more turbulent labor markets (Ljungqvist and Sargent, 1998; 2002). As the relative demand for unskilled labor diminishes, and governments or unions attempt to protect workers with low skills through labor market regulations or minimum wages, non-employment among the unskilled will increase (Bertola, 2003). Raising payroll taxes to support such efforts also reduces demand. Human capital policy can help to avoid the emergence of an underclass.

All available evidence shows that welfare state dependency in Europe is heavily concentrated among unskilled persons. For example, unskilled persons have higher unemployment rates, higher take-up rates of welfare benefits and larger participation rates in active labor market programs (OECD 2005a; 2006a; 2006b). In addition, many social problems are associated with lack of skill, such as deviant social behavior (drug use), working in the unofficial economy, criminal behavior, teenage pregnancies, and so on (European Commission, 2005). Social cohesion may be undermined further as migrant populations are predominantly low skilled and their welfare dependency rates are high.

Another feature of European labor markets is that European human capital stocks remain idle during large parts of the life-cycle due to non-employment and early retirement. Human capital needs be utilized and maintained over the life-cycle for human capital investments to earn a sufficiently high return. High levels of taxation, generous social benefits and strong labor market regulations reduce labor force participation rates, hours worked and employment and thereby lower the utilization rates of human capital. Generous early retirement and pension schemes make older people retire many years before statutory retirement ages (Gruber and Wise, 1999). Low labor force participation rates of older workers imply that the time-horizons over which investments in human capital are harvested are short. In addition, there are often weak economic incentives to maintain skills through training on-the-job. Insurance schemes for disability, unemployment, and sickness create important moral hazard problems. Once out of work, older workers will often never be able to find a new job. Due to population ageing, the utilization rate of European human capital falls and substantial parts of human capital stocks will be written off as workers retire.

Human capital policies can be efficient and equitable. In order to address the challenges imposed by skill-biased labor demand shifts resulting in larger wage-premiums for skilled workers, larger investments in human capital are efficient. Such a policy also contributes to

equality by containing the growing divide between the skilled and the unskilled. Interventions early on in the life-cycle have larger returns than interventions later on in the life-cycle. Once individuals drop out of secondary school, labor market institutions or government policies often prevent them from finding employment at established wage minimums. If the social objective is to maintain high levels of minimum income support and redistribution towards the poor, human capital policy helps to reduce dependency on welfare states. Only when individuals acquire sufficient human capital at the beginning of their life-cycles, they can avoid getting stuck in poverty and productivity traps later on in life.

In addition, policies to foster human capital cannot be seen in isolation from labor market policies, tax and benefit systems, and pension schemes. Current welfare state arrangements often create substantial implicit tax burdens on human capital investments because the incentives for investments in human capital are undermined by low utilization rates of human capital and short time horizons over which investments in skill materialize. Labor force participation, hours worked, training on-the-job and later retirement are all complementary to human capital investments. Reforms in labor markets, pension systems and tax-benefit systems may not only have beneficial static effects on labor market performance, but also have important dynamic efficiency gains by lowering implicit tax wedges on skill formation over the life-cycle.

We ground our policy analysis in insights from previous research on the technology of skill formation (Cunha, Heckman, Lochner and Masterov, 2006; Cunha and Heckman, 2007; Heckman, 2007). Human capital accumulation is a dynamic process. The skills acquired in one stage of the life-cycle affect both the initial conditions and the technology of learning at the next stage. Human capital is produced over the life-cycle by families, schools, and firms. Different stages of the life-cycle are critical to the formation of different types of abilities. When the opportunities for formation of these abilities are missed, remediation is costly, and full remediation is often prohibitively costly. These findings highlight the need to take a comprehensive view of skill formation over the life-cycle so that effective policies for increasing the low level of skills in the workforce can be devised.

The present paper extends this line of reasoning to the entire life-cycle. We argue that, due to the same dynamic complementarities in skill formation over the life-cycle, skill formation is impaired when the returns to skill formation are low due to low skill use and insufficient skill maintenance later on in life. We develop a theory of earnings, schooling, training and retirement which is capable of describing some stylized features of Europe's labor markets and illustrates the impact of various policies. The consequences of low skill formation both in the Anglo-Saxon world and mainland Europe are equally present. However, when it comes to skill use and skill maintenance, we show that mainland Europe differs

markedly from the Anglo-Saxon world due to low skill use and poor skill maintenance. Europe's future problems with low skills are therefore exacerbated by labor market institutions and government policies that lower utilization rates of human capital and promote steep depreciation of human capital over the life-cycle.

The rest of this paper is organized as follows. Section 2 gives some stylized facts on trends and developments that are crucial for devising an appropriate human capital policy for Europe. Section 3 summarizes the evidence on the technology of skill formation. Section 4 of develops a theory of skill formation, skill utilization and skill maintenance. Section 5 summarizes and gives some of the implications of our analysis for policy design.

2 Stylized facts on skill formation, skill use and skill maintenance in Europe

This section describes in detail some salient stylized facts on inequality, skill-formation, skill use and skill maintenance, between countries and developments over time. Wherever possible we distinguish among the Anglo-Saxon countries (United Kingdom, Australia, New Zealand, Canada and the United States), the Nordic countries (Denmark, Norway, Sweden, and Finland), Continental European countries (Netherlands, Belgium, France, and Germany) and Mediterranean countries (Portugal, Spain, Italy, and Greece).

2.1 Economic environment

2.1.1 Growing earnings and income inequality

Davis (1992), Gottschalk and Smeeding (1996), Katz and Autor (1999) and Brandolini and Smeeding (2006) analyze trends in earnings inequality and conclude that inequality has been steadily increasing in Western countries during the last decades of the twentieth century although the rapid growth in the 80's appears to level off in the 90's.[1] The increase in inequality is most notable in the Anglo-Saxon countries. The Nordic countries appear to have contained the increase in inequality. As noted by Bertola (2003) and Atkinson (2008), the rise in inequality countries is mainly concentrated in the upper part of the earnings distribution and not so much in the lower part of the earnings distribution. Gottschalk and Smeeding (1996) and Brandolini and Smeeding (2006) have shown that inequality in net disposable household income did increase as well but to a much lesser extent than labor earnings. Piketty and Saez (2003), and Atkinson and Salverda (2005) document large

[1]This finding is also reported for the US by Autor, Katz and Kearney (2008).

increases in earnings inequality at the very top of the income distribution for the US and the UK. Piketty (2003) and Atkinson and Salverda (2005) show that the income distribution at the top did not change much in France and the Netherlands.

2.1.2 Minimum wages, inequality and trade-off between equality and incentives in the labor market

Falling real minimum wages appear to have caused growing inequality at the bottom of the earnings distribution in the US, see also Autor, Katz and Kearny (2008). Minimum wages reduce inequality for workers at the cost of lower employment. Indeed, inequality at the bottom of the earnings distribution did not increase much for European countries but unemployment rates among low income earners have been increasing instead (Davis, 1992). Bertola (2003) shows that employment declines (unemployment rates increase) especially in those countries where inequality in the lower part of the earnings distribution remained rather constant. Increases in unemployment rates are disguised to an important extent by enrolling unemployed workers in active labor market and training programmes. Figure 1 from Heckman, Ljunge and Ragan (2006) shows that many European countries and especially corporatist countries (Denmark, Finland, Norway, and the Netherlands) almost halve their open unemployment rates by placing more unemployed workers in Active Labor Market (ALM)-programmes, where they are no longer counted as unemployed workers. Adding these trainees back to the unemployed substantially boosts the unemployment rate.

2.1.3 Trade-off between equality and incentives for human capital investment

Low inequality may not only be a virtue, but may also be a vice when low inequality reflects weak economic incentives. Figure 2 plots higher educational attainment rates of 25-34 year old cohorts against earnings inequality as measured by the 90/10 percentile ratio. Both variables are taken from the OECD Labor Force Database. A clear positive correlation emerges between earnings inequality and higher educational attainment. This positive correlation remains robust using tertiary educational attainment rates of 25-65 year old cohorts, employing 90/50 or 50/10 percentile ratios for inequality or doing panel regressions that allow for country-specific fixed effects. There is not only a trade-off between the *quantity* of employment and equality but also between the *quality* of employment and inequality. More compressed wage distributions imply weaker incentives for skill formation. Frederiksson (1997) is one of the few studies that directly estimates the effect of a larger skill-premium on enrollment and finds very substantial effects for Sweden. The empirical general equilibrium model for the US of Heckman, Lochner, and Taber (1998) also predicts a quite elastic

response of investments in human capital to larger skill premia.[2]

2.1.4 Rising returns to education

Income inequality is increasing in part because the returns to education display an upward trend. Studies for the US have documented a strong and steady increase in the college-premium during the 80's and 90's (Katz and Autor, 1999; Autor, Katz and Kearny, 2008). Peracchi (2006) reviews a large number of country studies and shows that in general skill premia have been constant or increasing in recent years for most Western countries. Gottschalk and Smeeding (1996) in their cross country comparison find that an important driving force behind growing earnings inequality is the growing skill-premium. Using a panel of selected OECD countries, Nahuis and De Groot (2003) show that rising skill-premia during the 80's and 90's are not only present in the US but in the whole of the Western world.[3]

By now there is a firmly established consensus that the mean rate of return to a year of schooling, as of the 1990's, exceeds 10 percent and may be as high as 17 to 20 percent (see Heckman, Lochner and Todd, 2006). This return is higher for more able people (Taber, 2001; Carneiro and Heckman, 2003) and for children from better backgrounds (Altonji and Dunn, 1996, present some evidence in support of this claim but their own interpretation is more equivocal). Those from better backgrounds and with higher ability are also more likely to attend college and earn a higher rate of return from doing so. This evidence is robust to alternative choices of instrumental variables and to the use of alternative methods for controlling for self-selection. Both cognitive and noncognitive skills raise earnings through promoting schooling and through their direct effects on earnings (see the evidence in Taber 2001; Heckman, Hsee, and Rubinstein 2001; Carneiro, Hansen, and Heckman 2001; 2003; Cunha, Heckman, Lochner, and Masterov, 2006; Heckman, Stixrud and Urzua, 2006; Borghans et al., 2008).[4]

[2]Numerous studies find only small impacts of larger tuition rates on enrollment (Kane, 1994, 1995; Hilmer, 1998; Heckman et al. 1998; Dynarski, 2003; Card and Lemieux, 2001; Cameron and Heckman, 2001). Part of the explanation is that tuition costs are a relatively minor fraction of the total costs of education since forgone labor earnings are by far the most important part (Becker, 1964). Another explanation is that psychic costs play a substantial role in explaining college choices (Cunha, Heckman and Navarro, 2005).

[3]Carneiro and Lee (2006) show that standard measures for skill-premia between higher and lower educated workers are even biased downwards due to selection into higher education on non-observed characteristics.

[4]Cunha and Heckman (2008) and Heckman, Lochner and Todd (2006) survey a large number of studies that show that nonpecuniary factors (associated with psychic costs, motivations and the like) play a major role in explaining why minorities and persons from low-income families do not attend college even though it is financially profitable to do so. Returns to schooling for marginal entrants attracted into college by changes in tuition are below those of the average participant. Returns to schooling are lower for people less likely to attend college.

2.2 Skill creation

2.2.1 Slowing down of the growth in supply of skills

Educational attainment has grown enormously in most of the Western world. Figure 3 plots higher educational attainment rates (as a fraction of each birth-cohort) over the 1960-1995 period for various countries from the De la Fuente and Domenech (2006) data set.[5] Enrollment rates doubled virtually everywhere. The development in the average number of years of education is similar (not shown). A striking feature is the large heterogeneity between countries in higher educational attainment. The Mediterranean countries lag miles behind the Nordic and Anglo-Saxon countries. The Continental European countries are somewhere in the middle. We have to note here that institutional differences between countries make good comparisons difficult due to, for example, differences in the duration of higher educational programmes. Literacy scores indicate that high levels of educational attainment in some countries do not necessarily match with high levels of literacy (Heckman and Jacobs, 2006). Education systems differ across different countries and these comparable tests may provide a better measure of the stock of skills of a country, at least for the purpose of international comparisons. Hanushek and Kimko (2000) use these tests as a measure of the quality of the labor force and argue that these are an important determinant of economic growth.

The massive increase in the level of education of Europe's workforces probably cannot be maintained indefinitely. Figure 4 shows that there are strongly decreasing returns to raising education levels as the growth rate of in education levels during 1960-1995 is negatively correlated with the initial level of education in 1960. Therefore, one can expect that the returns to education will be rising in the years to come because the demand for college educated workers outstrips supply.

2.2.2 Resources invested in human capital are not increasing

Resources invested in human capital in Europe also remain rather stagnant despite the rising returns. Overall investment levels as a fraction of GDP do not change much over time in Continental and Mediterranean countries, see Figure 5. Notable are the decreases in some countries (Finland and Norway). The financial resources per student in higher education invested are again roughly constant in Continental European and Mediterranean countries. In Anglo-Saxon and Nordic countries, resources invested in higher education have increased in recent years (see OECD, 2005a).

[5] De la Fuente and Domenech (2006) have constructed a panel data set for OECD countries of educational attainment for various education levels and average years of education based on data from national statistical offices which are supplemented by data from the OECD.

Figure 6 plots the share of private contributions to the direct costs of education for different countries. Virtually all European countries heavily rely on state funding for education and that is probably also the reason why public budgets haven't kept pace with increasing enrollment rates in some countries. Primary and secondary education are generally free everywhere. As regards higher education, tuition is subsidized and students receive (means tested) grants and study loans with interest subsidies. Again, only the Anglo-Saxon countries have a non-trivial share private investments whereas especially the Nordic and Mediterranean countries almost exclusively rely on state funding for education.

Although larger skill premia would naturally give stronger incentives to invest in more human capital, it is by no means certain that this will also happen in the stiffly regulated higher education sectors in Europe. Due to the ageing of the population and the EMU-criteria for deficits and debts, most government budgets are under pressure. There is currently not much hope for extra public funding whereas there are good reasons for more private investments in higher education. Nevertheless, most governments obstruct private funding by repeatedly raising accessibility issues and failing to understand the basic incentive issues facing schools and students (see Jacobs and Van der Ploeg, 2006).

Larger private funding of education is efficient if governments do not free up enough resources for investment in human capital, especially in higher education. There is a strong efficiency case for public support in primary education in well-developed welfare states. Poverty traps create not only large tax burdens on work effort but also on skill formation; if it does not pay work it does not pay to invest in skills either. If the social objective is to maintain welfare states and income support programs for the poor, sufficient investments in human capital lift vulnerable groups above the minimum income floors (Bovenberg and Jacobs, 2003). This public support may come in the form of public funding for primary and secondary education, but also in the form of minimum school leaving ages and outlawing child labor.

2.2.3 Skill-biased demand for labor

The sharp increase in educational attainment in some countries in Europe has put downward pressures on skill-premia. That is probably why returns to education have not been rising so much in some European countries as opposed to the US where growth in the supply of skilled workers choked off already in the 90's (Carneiro and Heckman, 2003; Autor, Katz, and Kearney, 2008). Nevertheless, overall wage inequality did increase and returns to education certainly did not decrease to a large extent. Gottschalk and Smeeding (1996) and Peracchi (1996) show that skill-premia remained rather constant in most countries and generally increased in recent years. Everywhere in Europe labor markets have absorbed the

enormous influx of skilled workers without large reductions in skill-premia. In other words, the demand for skilled workers has been increasing at the same or even higher speed than the supply of skilled workers. Many explanations have been put forward for these labor demand shifts but skill-biased technical changes appears to be the most important one. Increasing international trade and capital-skill complementarities could be supplementary explanations for this phenomenon, see also Katz and Autor (1999).

The outward shift of relative demand for skilled workers is radically transforming labor markets and economies. To get an impression of its quantitative importance one may ask the counterfactual question how much wage differentials would have increased had the supply for skilled workers remained constant. In the US wage differentials between skilled and unskilled workers would have increased at a rate of 3% per year (Katz and Murphy, 1992) and about the same is found for Canada (Murphy, Riddell and Romer, 1998). Jacobs (2004) documents a skill-bias of about 2% per year in the Netherlands. A skill-bias of a 1% increase in college premium per year is found in Sweden by Edin and Holmlund (1995).

2.2.4 Low skilled workers have weak incentives to train

Unskilled individuals receive little training on the job, either because they opt out of it when it is offered to them, or because employers choose to offer training to workers with better skills. This is illustrated in Figure 7, from OECD (2003), which shows the proportion of people at each literacy level who receive job training. A low score signifies a low level of literacy. As emphasized by Carneiro and Heckman (2003), there are strong complementarities between early human capital investments and adult human capital investments. Low skilled workers have difficulty in benefiting from adult training because they have a low stock of human capital on which adult investments can build on and be productive. Remediation investments in adulthood are very costly and ineffective for low skilled individuals (Knudsen, Heckman, Cameron and Shonkoff, 2006; Cunha, Heckman, Lochner and Masterov, 2006). Preventive investments that take place earlier in the life-cycle of individuals generate much larger returns.

2.2.5 Large spending active labor market programmes

Many European governments spend large amounts of resources on active and passive labor market programmes, as demonstrated in Figure 8. Continental European countries lead in total spending, followed by the Nordics. Mediterranean countries have some labor market programmes, especially Spain. Anglo-Saxon countries have virtually no labor market programmes compared to the rest. Below we will argue that these programmes are largely

ineffective in lifting individuals out of poverty and raising their standards of living.

2.2.6 Taxes, subsidies and the incentives to acquire skills

Flat labor income taxes do not harm skill formation as long as all costs are subsidized or deductible at the flat income tax rate. Direct costs and the opportunity costs of education – forgone labor earnings while in education – are then taxed at the same rate as the future labor earnings (Heckman, 1976). Only if marginal costs are taxed at lower rates than the marginal benefits, tax distortions on skill formation emerge. If marginal tax rates on labor incomes are increasing with income, future earnings are taxed at higher rates than forgone labor earnings and taxation discourages investment in human capital. This is the case in most European countries, see also Figure 16 which shows that Musgrave and Musgrave's coefficient of residual income progression is generally below one.[6]

Also, if education requires non-deductible expenses or effort costs, labor taxation reduces investment in human capital. Education expenses for formal schooling or training are generally not deductible for the income tax. Some exceptions occur in Italy, the Netherlands and Portugal (see also Gordon and Tchilinguirian, 1998). Large subsidies on education and training do however correct for tax disincentives on skill formation (Bovenberg and Jacobs, 2005). Indeed, many governments seem to over-subsidize higher education from a fiscal perspective, i.e., there is a net subsidy rather than a net tax on education and training (De la Fuente and Jimeno-Serrano, 2005; Bovenberg and Jacobs, 2005). Costs of training on-the-job are generally deductible by firms.

Non-pecuniary costs and benefits escape the tax system and cannot be subsidized either. Given the high returns on human capital investments, one is tempted to conclude that non-pecuniary costs of education appear to be empirically more important than the non-pecuniary benefits. Findings by Carneiro et al. (2001, 2003) and Cunha, Heckman and Navarro (2005) surveyed in Cunha, Heckman, Lochner and Masterov (2006) suggest that non-pecuniary costs can be very important indeed. Therefore, it can still be the case that taxation distorts skill formation even though direct costs are heavily subsidized. Additionally, large subsidies on observable inputs in human capital formation (like years enrolled in education) will crowd out non-subsidized complementary inputs in human capital formation like study effort (see Bovenberg and Jacobs, 2005; Jacobs, 2007). High subsidies on education may then go hand in hand with long study durations, high drop-out rates and low student performance.

Finally, labor income taxation depresses labor supply and thereby the utilization rate of human capital. Consequently, labor income taxation indirectly depresses human capital

[6]This coefficient gives the ratio (1 – marginal tax rate)/(1 – average tax rate) and is smaller than one if the marginal taxes are higher than average taxes.

investments, even if all costs are deductible and labor taxes are flat, see also Jacobs (2005, 2007).

2.2.7 Slowing growth in skills lowers productivity growth

Researchers have established a robust, causal relation between education and earnings at the microeconomic level (see for example Card, 1999; Harmon, Oosterbeek and Walker, 2003; Heckman, Lochner and Todd, 2006) although there is a debate about the magnitude of the relationship. A growing body of evidence suggests that the macroeconomic returns are of the same magnitude as the conventional microeconomic estimates (Heckman and Klenow, 1998; Sianesi and Van Reenen, 2002; Krueger and Lindahl, 2001; De la Fuente and Doménech, 2006; Ciccone and Peri, 2006). The fact that education appears to be roughly equally productive at the macroeconomic level as at the micro-level largely disqualifies the 'signalling-hypothesis' as put forward by Arrow (1973).[7] Skills are crucial determinants of labor productivity. These findings can also be taken as evidence that — at current levels of public spending — external effects of education are absent. Figure 9 gives the average annualized growth rates of labor productivity during the last 20 years. This graph shows that the Continental European and Mediterranean Countries have witnessed the lowest rates of productivity growth. Unsurprisingly, the countries with large levels of investment in human capital (Nordics and Anglo-Saxon countries) appear to generate the highest levels of productivity growth. A slowdown in the rate of skill acquisition therefore appears to threaten the standards of living of future generations.

2.3 Skill utilization

2.3.1 Small labor force attachment reduces the utilization rate of human capital

A possible reason for low average returns to education is that labor force participation rates are low. This causes acquired human capital to remain idle. Hence, a lower utilization rate of human capital reduces the returns to investments in schooling and training.[8] Figure 10 shows that labor force participation rates are lowest in Mediterranean and Continental European countries. Nordic and Anglo-Saxon countries have higher participation rates. However, labor force attainment has been increasing in recent years in many countries as women started to participate in especially the Nordic and Continental European countries. Growth in participation rates was more modest in Anglo-Saxon countries where participation rates

[7] This was first noted by Heckman and Klenow (1998).

[8] Standard measures for the returns to education or the skill premium rarely allow for the utilization rate of human capital, however.

were already high. Mediterranean countries seem to be stuck in a trap of low participation rates.

Labor force attachment strongly increases with the level of education as can be seen from Figure 11. This patterns holds across all countries. Although often overlooked in the human capital literature, an important benefit of higher skills is therefore the increased labor force attachment of more educated workers, especially in Europe where employment rates are low. The mirror image is that there is a strong dependence of unemployment on the level of education (graph not shown). As already noted before, official unemployment statistics are misleading because many countries enroll unemployed workers in ALM programmes, see Figure 1 from Heckman, Ljunge and Ragan (2006). The latter authors show that real unemployment rates can be twice as high as official statistics suggest. Some corporatist countries may just be good in hiding unemployment.

European countries have also hidden a lot of unemployment in sickness and disability benefits. Figure 12 gives the non-employment rates of disabled workers as a fraction of the population aged 20-64. This depressing picture shows that a fraction of around 8% of the population aged 20-64 receives a sickness or disability benefit and does not work. Large fractions of workforces are disabled or sick and not participating in the labor market especially in the Netherlands, Germany, Portugal, Denmark, Sweden and the UK where the rate of sickness/disability is around 10% or higher. Disability related expenditures are especially high in the Netherlands and some Nordic countries (between 4-5% GDP). The other Continental European countries and the Anglo-Saxon countries do not have a lot of disability spending: between 1-2% of GDP (OECD, 2005c).

2.3.2 Falling working hours lower utilization rates of human capital

Not only is the employment rate of European workforces low in comparison to the Anglo-Saxon world, but also hours worked. This fact is documented many times and one of the suggested reasons is the high level of taxation. However, also unionization of labor markets and collective labor agreements on reductions in working hours and holidays matter (see, for example, Prescott, 2004; Alesina, Glaeser and Sacerdote, 2005). The average number of hours worked is falling quite steadily over time in many countries in the last two decades (OECD, 2006a). The only exception is Sweden where average hours worked actually increased. Anglo-Saxon countries featured rather stable patterns of hours worked over time with the exception of the UK. Part of this development is the mirror image of increasing labor force participation rates by female workers who tend to work more in part-time jobs (OECD, 2006a). This pattern cannot readily be explained by increasing tax rates everywhere because tax rates have been falling in recent years in many countries, see also Figure 16.

2.3.3 Generous benefit entitlements reduce employment

Replacement incomes when unemployed can be high as indicated in Figure 13. Replacement incomes for the pool of the unemployed in Nordic and Continental European countries are around 50-60% of earned income. Anglo-Saxon countries have much lower replacement rates in the order of 20% of earned income or even less on average. The Mediterranean countries are in the middle with replacement rates of about 30% with a notable exception of Italy. Figure 14 shows how eligibility for unemployment benefits changes over time. Individuals quickly loose their benefits in the Anglo-Saxon, Nordic and Mediterranean countries. Only in the Continental European countries unemployment benefits often extend to 5 years or more without large reductions in benefit levels.

Theoretical work by Layard et al. (1991), Bovenberg and van der Ploeg (1994), Pissarides (1998), Sørensen (1999) and others, shows that larger replacement benefits reduce employment in both competitive and non-competitive labor markets characterized by unions, efficiency wages or matching frictions. In a neoclassical world, unemployment benefits lower labor supply through income effects and act as subsidies on leisure. In labor markets with unions, higher replacement rates raise unions' wage demands and this lowers employment. In labor markets with frictions or efficiency wages, higher replacement incomes increase reservation wages for workers and thereby lower employment as workers receive higher wages. So both in competitive and non-competitive labor markets, higher (unemployment) benefits reduce employment (or increase unemployment).

Generous benefit entitlements are probably one of main the reasons why unemployment rates are high, but also contributing are extensive duration of benefits, strict labor market regulations with respect to hiring and firing of workers, and large union coverage. See Layard et al. (1991) and Nickell (1997). The main problem however with these macroeconomic studies is that the time-series variation within countries is rather limited and identification of effects heavily relies on the cross-country dimension. Adding country fixed effects often destroys the cross-country correlations found, see also Van Ours and Belot (2001) and Blanchard (2006).

In contrast to the macroeconomic literature, a pile of microeconomic studies suggests that employment sharply decreases with the generosity and duration of benefits because workers search less actively for work both in the US and in European countries, see the overview in Lalive et al. (2006) and the estimates they present. Abbring et al. (2005) and Lalive et al. (2005) and the numerous papers they cite, find that sanctions on benefit levels and durations may be highly effective in getting unemployed workers back to work.

Some recent studies document strong cohort effects in the take-up rates of benefits (Lindbeck and Nyberg, 2006; Ljunge, 2006). Younger generations are more likely to collect some

benefit than older generations which can be due to the erosion of work ethic.[9] These arguments provide an alternative explanation for the high level on which European unemployment rates have been stuck since the end of the 1980's.

2.3.4 Labor market protection harms labor market performance

Figure 15 gives the OECD summary statistic on labor market regulations. This statistic summarizes the severity of legal restrictions on hiring and firing, flexibility in labor contracts, working time restrictions, minimum wages, and employees' representation rights (work councils, company boards). Mediterranean countries have the least flexible labor markets, followed by the Continental European countries. Nordic countries, and especially Denmark, appear to have more flexible labor markets. It goes without saying that the Anglo-Saxon countries have most flexible labor markets in the world.

Measures of labor market protection appear to be associated with bad labor market performance in macroeconomic studies (see Layard et al. 1991; Nickell, 1997). Again, time-series variation in these cross-country panel analyses is often too limited and solid conclusions cannot be drawn in general. Heckman and Pagés (2003, 2004) present evidence from microeconomic studies for Latin American countries to assess the impact of labor market regulations. They find that job security regulations indeed have large efficiency costs. In addition, the distributional consequences appear to be perverse. Insiders gain from labor market regulations at the expense of outsiders: young and unskilled workers. However, using a panel of both Latin American and OECD countries and exploiting exogenous variation induced by various policy reforms, the macroeconomic evidence on the impact of labor market regulations remains fragile. Payroll taxes are the only really robust variable in explaining lower employment and higher unemployment rates.

2.3.5 Large tax burdens weaken labor market performance

Figure 16 gives the average and marginal tax burdens on earned income including the value added or sales taxes. Large average and marginal tax burdens suggest that labor supply is distorted substantially (Prescott, 2004; Alesina et al. 2005). Marginal tax rates are generally in the order of 60–70% in Continental European and Nordic Countries. Marginal tax rates are substantially lower in the Mediterranean countries and the Anglo-Saxon world. Here, the Continental European Countries have the steepest graduation in tax rates. The other countries are relatively close in terms of tax rate progression.

[9]These findings are consistent with a 'social multiplier' for leisure demand as hypothesized by Alesina et al. (2005).

A huge micro literature shows that high levels of taxation depresses labor supply in terms of hours worked. See Pencavel (1986), Killingsworth and Heckman (1986), and Blundell and MaCurdy (1999), for extensive overviews. Substitution effects in labor supply are dominant (especially for women) and income effects appear to be modest. Much less empirical evidence can be found on the effects of taxation on other choice margins than hours worked. As stressed by Heckman (1993) and Saez (2002), the participation ('extensive') margin is more elastic than the hours worked ('intensive') margin. Taxation potentially also affects human capital formation, search efforts of the unemployed and wage setting institutions.

The effects of higher taxes on labor earnings are not clear-cut in non-competitive, European style labor markets. Typically, in non-competitive labor markets the wage level and the unemployment rate increase if marginal tax rates are lower, average tax rates are higher, and benefit levels/replacement incomes are higher – ceteris paribus.

Higher marginal taxes generally increase employment for given average taxes and labor supply. See Bovenberg and van der Ploeg (1994), Sørensen (1999), Pissarides (1998), Bovenberg (2006), and Van der Ploeg (2006). Unions are punished when seeking higher wages in response to higher marginal tax rates as the government taxes away wage increases at higher rates. This force moderates wage demands, labor demand expands and unemployment falls. In labor markets characterized by search frictions, marginal tax rates can boost employment. Since workers and firms Nash-bargain over the surplus of firm-worker matches, workers capture less of the surplus when marginal tax rates increase. Firms need to pay a higher gross wage to provide a given net wage to the worker. And, conversely, workers need to accept a lower net wage to maintain a given level of profits for the firm. Hence, the negotiated wage falls, labor demand expands, labor market tightness increases, and equilibrium unemployment falls. In market environments characterized by efficiency wages, firms find it harder to recruit, retain or motivate workers by increasing wages when governments tax away these wage increases at higher rates. Therefore, firms pay lower wages, labor demand expands and equilibrium unemployment falls.

Higher average income taxes – for given marginal tax rates – may also have opposite effects in comparison with neoclassical models, depending on the response of the net replacement rate to higher taxes. See Bovenberg and van der Ploeg (1994), Sørensen (1999), Pissarides (1998), Bovenberg (2006) and Van der Ploeg (2006). A higher average income tax increases net replacement rates (net benefit divided by the net wage rate) if benefits are untaxed. In response to higher average taxes, unions will demand higher wages as the position of their working members worsens in comparison with the non-working members, so that unemployment rates go up. Firms paying efficiency wages see that it becomes more difficult to recruit, retain or motivate workers because net replacement rates increase. As

a result, labor costs rise and equilibrium unemployment increases. With search frictions, higher average tax rates on wage income increase wage demands of workers, which pushes up wage costs for firms, labor market tightness falls and unemployment increases. However, when benefits are indexed to net wages, replacement rates remain fixed and unions, firms or workers do not change wage setting behavior (a lot) and there are much smaller (or even zero) effects of higher average tax rates on unemployment.

Most of the theoretical papers cited above analyze non-competitive labor markets where labor supply is treated as exogenous, thereby overstating the case for tax progression. Sørensen (1999, p.449) demonstrates that the welfare gains of tax progression in union and efficiency wage models are virtually negligible when the compensated wage elasticity of labor supply approaches lower bounds found in the empirical literature (around .20/.25). See Browning, Hansen and Heckman (1999) and Blundell and MaCurdy (1999) for evidence on this question. Indeed, Sørensen's findings suggest that deviations from a flat rate income tax to cushion labor market distortions are quite costly in terms of reduced labor supply. Sørensen (1997) develops a CGE-model for Denmark. He analyzes larger tax credits for low wage earners, financed by raising marginal tax rates on all labor incomes. This policy, which makes the tax system more progressive, has ambiguous welfare effects, depending critically on elasticities of the wage equation with respect to marginal and average tax rates on wages. Bovenberg et al. (2000) develop a detailed CGE-model for the Netherlands, which incorporates labor supply on the intensive and extensive margins, on-the-job training, search frictions and wage-setting by unions. They demonstrate that the negative (positive) effects of high marginal (average) tax burdens on labor supply and training are outweighed by the small positive effects arising from wage moderation and reductions in labor market frictions.

The possibility of setting wages above the market clearing level depends on the ability of consumers or workers to shift taxes to firms. Most theories of wage determination in non-competitive labor markets show that the wage mark-up over the market clearing wage declines if the labor demand elasticity increases, i.e. when it is more difficult to shift taxes towards firms, see for example Bovenberg (2006) and Van der Ploeg (2006). In small open economies with perfect capital mobility and perfectly competitive goods markets, it is not possible to shift the tax burden to firms; labor demand would be perfectly elastic at the world wage rate. Thus, the distortions created by unions, search frictions, and efficiency wages could be less relevant for many small open European countries.

Finally, to fully understand the effects of taxes in distorted labor markets, one should not only focus on changes in tax-rate progression for *given* levels of benefits and average tax rates, as most of the aforementioned papers do. Empirically, larger marginal tax rates are strongly associated with higher non-employment benefits and higher average tax burdens.

See Figure 13 and Figure 16. A policy of increasing marginal taxes, while using tax revenues to finance benefits or larger levels of public spending (so that average tax rates increase) generally reduces labor supply and employment in both competitive and non-competitive labor markets.

To conclude, it is not clear that taxation is always less harmful in non-competitive than in competitive labor markets. This depends on how responsive labor supply is, how much of the incidence of taxes can be shifted to firms, and how tax revenues are spent.

2.4 Skill maintenance

2.4.1 Decreasing retirement ages causes quicker depreciation of skills

Apart from labor force participation and hours worked, the age of retirement also constitutes an important element of the utilization of human capital over the life-cycle. At retirement, human capital is written off completely. If workers retire later, they will have larger returns on their investments in education and training on-the-job as the time-horizon over which the investments mature expands.

Figure 17 shows that that labor force attachment of the average worker is rapidly declining with age. This development is also carefully documented by Gruber and Wise (1999). Labor force participation rates of 55-64 year old workers are only in the order of 1/2 or even less. Especially the Continental European and Mediterranean countries have low participation rates of older workers. Nordic countries outperform the Anglo-Saxon countries as regards the labor force participation rates of 55-59 year old workers, but the Anglo-Saxon countries do better in the 60-64 year cohorts.

Figure 18 shows the development of labor force participation rates of cohorts of workers aged 55-59 year. Generally the labor force participation rates have been falling and show a turn around in recent decades. However, if there has been an increase in overall labor force participation rates of 55-59 year old cohorts, it is mainly driven by the general increases in female force participation rates. Belgium (slightly), Denmark, Finland and the Netherlands are the only four countries who have witnessed both an increase in male and female labor force participation rates and in recent years which is probably due to policy changes in early retirement schemes.[10]

[10] All countries have witnessed declines of labor force participation rates of 60-64 year old cohorts (not shown). Dramatic declines are found in Finland, France, Germany, Netherlands, and Spain. In Australia, Canada, Denmark, Norway, Sweden, and the United States the decline is to an important extent offset by increases in female force participation. In the other countries this offsetting effect has been largely absent as female participation rates were falling too. However, recent increases in Canada, Netherlands and Sweden (as from 1990) are the result of increasing male *and* female labor force participation rates. This is, again, likely to be the result of changes in early retirement schemes.

Figure 19 plots the effective age of retirement, conditional upon being in the labor force. There has been a landslide in effective retirement ages. Over the last 40 years effective retirement ages went down massively everywhere in the Western world, including the Anglo-Saxon countries. Again, the Continental European countries have witnessed the largest decreases in the retirement ages (see also Gruber and Wise, 1999). In recent years we see that the decrease in effective retirement ages has come to a halt at a low plateau.

Figure 20 shows that labor force participation rates of 55-59 and 60-64 year old cohorts are much higher when individuals have more initial education. Better skilled workers retire much later. This graph reinforces our notion that labor supply and skill formation over the life-cycle are strongly complementary activities.

2.4.2 Generous pensions and early retirement schemes reduce labor force participation of older workers

Pension benefits can be generous as is clear from Figure 21. Pension replacement incomes in Continental European are quite high and about 60-80% of pre-retirement earnings for an average worker. Mediterranean countries have exceptionally generous pension schemes which entail pension benefits of 80-100% of last earnings (up to 100% in Greece). The Nordics, on the contrary, have much more modest pension benefits in the order of 40-60% of pre-retirement earnings. The Anglo-Saxon countries have on average the lowest pension benefits which are around 40-50% of final earnings. Another interesting feature is that 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 (2005d). Note finally that net pension incomes are always larger than gross pension incomes. The reason is that all governments give tax-deductions or subsidies on pension savings.

Many workers retire long before statutory retirement ages via all kinds of early-retirement schemes. It is not easy to make international comparisons because the institutional details vary from country to country. However, we can summarize the impact of early retirement schemes on the labor market by the implicit marginal tax rates imposed on an additional year of work (see also Gruber and Wise, 1999). Figure 22 shows that early retirement schemes do indeed cause very high marginal tax rates on pre-retirement incomes.[11] Moreover retirement ages and benefit generosity are very negatively related. Gruber and Wise (1999) present

[11] We have to note that some countries have started to reform their early retirement schemes in recent years, for example in the Netherlands. The graph may therefore give a too pessimistic view of the adverse incentives to retire early.

strong evidence that this is a causal relation. It should therefore not come as a surprise that the Continental European and Mediterranean countries have low labor force participation rates of elderly workers because they have the most generous early retirement schemes. In recent years some countries have reformed their pension schemes. The Netherlands, Germany, France, and Italy are examples. Labor force participation of older workers appears to be picking up in recent years in some countries due to reforms, general trends such as rising female labor force participation, or because workers anticipate future reforms.

3 The technology of skill formation[12]

Figure 23 summarizes the major theme of Heckman (2000) and Carneiro and Heckman (2003). It plots the rate of return to human capital at different stages of the life-cycle for a person of given abilities. The horizontal axis represents age, which is a surrogate for the agent's position in the life-cycle. The vertical axis represents the rate of return to investment assuming the same amount of investment is made at each age. *Ceteris paribus* the rate of return to a dollar of investment made while a person is young is higher than the rate of return to the same dollar made at a later age. Early investments are harvested over a longer horizon than those made later in the life-cycle (Becker, 1964). In addition, because early investments raise the productivity (lower the costs) of later investments, human capital is synergistic. Learning begets learning; skills (both cognitive and noncognitive) acquired early on facilitate later learning. Early deficits make later remediation difficult. Finally, young children's cognition and behavior are more easily malleable than cognition and behavior in adults. For an externally specified opportunity costs of funds, an optimal investment strategy is to invest relatively less in the old and relatively more in in the young. A central empirical conclusion of their analysis is that at current investment levels, efficiency in public spending would be enhanced if human capital investment were directed more toward the disadvantaged young who do not receive enriched early environments, and less toward older, less-skilled, and illiterate persons for whom human capital is a poor investment.

Abilities are multiple in nature. They are both cognitive and noncognitive. Both cognitive and noncognitive abilities matter in determining participation in crime, teenage pregnancy, drug use and other deviant activities. These abilities are themselves produced by the family and by personal actions. Both genes and environments are involved in producing these abilities. Environments affect genetic expression mechanisms (see, e.g., Turkheimer,

[12]This section draws upon research by Heckman (2000); Carneiro and Heckman (2003); Cunha, Heckman, Lochner and Masterov (2006); Carneiro, Cunha and Heckman (2005); and Cunha and Heckman (2007, 2008) that develops the economic foundation for skill acquisition in modern economies.

Haley, Waldron, D'Onofrio and Gottesman, 2003; Björklund, Lindahl and Plug, 2006). This interaction has important theoretical and empirical implications for skill policies. It suggests an important role for environment-enriching policies in fostering human skills. Differences in cognitive ability across family types appear early and persist over time (Carneiro and Heckman, 2003; Cunha and Heckman, 2007). Measured cognitive ability is susceptible to environmental influences, including in utero experiences. Education barely affects test score gaps by family income or socioeconomic status after the early years of schooling (Carneiro and Heckman, 2003; Cunha, Heckman, Lochner and Masterov, 2006; Raudenbush, 2006).[13]

Noncognitive abilities such as motivation, self-discipline, and time preference — associated with the development of the prefrontal cortex — are also affected by environmental influences. Noncognitive abilities and cognitive abilities affect schooling attainment and performance, and a wide array of behaviors. Using a novel empirical approach, Heckman, Stixrud, and Urzua (2006) identify a low dimensional vector of latent cognitive and noncognitive skills which explains a diverse array of social and labor market outcomes. For many dimensions of social performance, cognitive and noncognitive skills are equally important. Heckman and Rubinstein (2001) and Heckman, Hsee and Rubinstein (2001) and Heckman and LaFontaine (2006) study the GED program[14] and show that the cognitive ability of GED participants is on average equal to that of high school graduates who do not enroll in college and even higher than the ability of high school drop-outs. However, GED recipients earn *less* than high-school drop-outs once the analyst controls for cognitive abilities. Consequently, noncognitive ability appears to be an important determinant of earnings which GED recipients lack. As is true for cognitive skills, gaps in noncognitive skills (motivation, trustworthiness, behavioral skills) emerge early and are substantially reduced once long-run family factors influencing the child's early years are controlled for (Carneiro and Heckman, 2003). I.Q. is fairly well set by age ten. Noncognitive abilities are more malleable over the life-cycle than cognitive abilities.

Much of the effectiveness of early childhood interventions comes in boosting noncognitive skills and fostering motivation (see, e.g., Heckman, Malofeeva, Pinto, and Savelyev, 2009). Short-term increases in cognitive skills (test-scores) fade out over time. Successful programs increase noncognitive skills and result in more social behavior and less crime. Programs

[13]In the popular literature, achievement tests and IQ tests are often confused. Achievement test scores are affected by IQ, schooling inputs, and noncognitive skills, and are malleable over a much greater range of ages than is IQ (see Hansen, Heckman, and Mullen, 2004; Cunha and Heckman, 2008; and Cunha, Heckman and Schennach, 2010). Abilities have an acquired character although they differ in their malleability at different ages.

[14]The General Educational Development (GED) program allows secondary-school individuals to obtain certification through an equivalency exam administered to dropouts which is comparable to a high-school degree.

are more successful if parents are part of the treatment, which bolsters the notion that improvements in the home environment have long-lasting effects. For overviews of the literature and evidence on a diverse array of early intervention programs, see Heckman (2000), Cunha, Heckman, Lochner and Masterov (2006), Carneiro and Heckman (2003) and Cunha, Heckman, Lochner and Masterov (2006). Given the quantitative importance of noncognitive traits, social policy is more effective in attempting to alter them especially for children from disadvantaged environments who receive little encouragement and discipline at home.

Interventions in adolescent years partially remediate but do not remedy insufficient early childhood investments at current levels of investment. Just as early intervention programs have a high payoff primarily because of the social skills and motivation they impart to the child and the improved home environment they produce, so do interventions that operate during the adolescent years, and for many of the same reasons. The impacts they achieve are modest, but positive.

One cannot expect substantial benefits from public job training programs which primarily targeted to disadvantaged workers. Surveying mainly microeconomic studies, Heckman, Lalonde and Smith (1999); Martin and Grubb (2001); and Calmfors, Forslund and Hemström (2001) conclude that these programs are largely ineffective.[15] The comparison of job training programs suggests a few important lessons. First, you get what you pay for. The recently terminated JTPA program in the U.S. cost very little but produced very few results. An exception to the rule is classroom training, for which the returns are substantial (Heckman, Hohmann, Khoo and Smith, 2000). Second, the effects of treatment vary substantially among subgroups (Heckman, LaLonde, and Smith, 1999). Third, job training programs also have effects on behavior beyond schooling and work that should be considered in evaluating their full effects. Reductions in crime may be an important effect of programs targeted at male youth. The evidence summarized in Heckman, LaLonde, and Smith (1999) indicates that the rate of return to most U.S. and European training programs is far below 10 percent, although the benefits to certain groups may be substantial. Some programs survive a cost-benefit test, but many do not. And even the most successful programs have only small impacts on poverty rates and few are lifted out of it. The study by Calmfors, Forslund and Hemstöm (2001), presents an extensive overview of the Swedish experience with active labor market policies and they conclude that ALMP have been inefficient. Public job training to remedy or alleviate substantially skill deficits that arise at early ages are generally ineffective.

Returns to human capital investments are highest for investments in children from dis-

[15]Some macroeconomic cross-country studies by Layard, Nickell and Jackman (1991) and Nickell (1997) suggest that active labor market programmes can be effective in reducing unemployment rates, but these studies do not control for country-specific effects.

advantaged families where children receive inadequate parental resources (Heckman, 2006; Heckman and Masterov, 2006). Universal programs generate dead weight because children from advantaged families receive substantial parental investment. Politicians face a practical problem of the transition. Older persons and disadvantaged younger persons are unemployable at current wage minimums. Investing in them has a low economic return. Carefully constructed wage subsidies are more effective in providing them with dignity and social inclusion, and to benefit from what they can offer society at large, see also the essays in Phelps et al. (2003). If such subsidies are not cohort-specific and phased out over time, newer generations will have weaker incentives to develop skills and poverty will perpetuate for a longer time across generations.

4 A theory of skill formation, skill use and skill maintenance

How can we reconcile the empirical findings of the European experience with theory? In this section we develop a partial equilibrium life-cycle model of schooling, on-the-job training, labor supply, saving and retirement. By simultaneously analyzing schooling, training labor supply and retirement decisions, the model allows us to spell out various complementarities over the life-cycle. First, we show that human capital investments feature dynamic complementarities over the life-cycle even after initial education. Both initial schooling and later on-the-job training are complementary activities. The returns to initial schooling are larger when individuals engage more in on-the-job training later on during their working careers. And, individuals will invest more in on-the-job training when they have more initial schooling. Second, complementarities exist between skill formation and labor market participation in its broadest sense. That is, the more individuals work and the later they retire, the larger will be the returns to investments in initial schooling and on-the-job training. The reason is that the costs of leisure and retirement increase when individuals become better skilled. Also the reverse holds. Later retirement and more hours of work boost skill formation by increasing its financial rewards. Our model builds on Mincer (1974) and Ben-Porath (1967) and adds an endogenous retirement decision. We focus on labor supply on the intensive (hours) margin and retirement.[16]

We maintain the assumption of full employment as labor markets are perfectly competitive and frictionless. We acknowledge at the outset that this is probably not the best description of the labor markets in Europe, but economic theory does not provide us yet

[16]For simplicity of exposition we do not work with the more general model of skill formation developed and estimated by Cunha, Heckman, and Schennach (2010)

with useful models that allow for the joint determination of labor supply, human capital formation and wages in non-competitive labor markets.[17]

4.1 Model

We assume that a representative individual is born at time $t = 0$ and has a life-span T which is exogenously given. This individual undergoes S years of initial education at the beginning of his life. Then the individual works. After the working career the individual retires at date R. The life-time time constraint states that total time in school S, in the labor market $(R - S)$ and in retirement $(T - R)$ should equal the life-span T of the individual:

$$T = S + (R - S) + (T - R)\,. \tag{1}$$

At each date, the individual derive instantaneous utility $U(C_t)$ from consumption C_t. To simplify the analysis we assume that only when the individual is in the labor market $(S < t \leq R)$ does he derive utility form leisure $\mathcal{L}_t$, i.e., $V(\mathcal{L}_t)$. Similarly, the individual does not engage in training-on-the-job before entering the labor market and stops with on-the-job training when he leaves the labor market. The time constraint while working states that the fraction of time working L_t, plus the fraction of time invested in training I_t plus the fraction time of time consumed as leisure $\mathcal{L}_t$ should be equal to the total time endowment – which is normalized to one:

$$1 = L_t + I_t + \mathcal{L}_t, \qquad S < t \leq R. \tag{2}$$

Alternatively, one could interpret L_t as the labor force participation rate, I_t as aggregate training efforts, and $\mathcal{L}_t$ as the non-employment rate in this representative agent setting.

Individuals derive utility $X(T-R)$ from the years they are retired $T-R$ where R denotes the retirement age. Retirement is a discrete decision to exit the labor market completely. The individual does not derive direct (dis-)utility from being in school.

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

$$\int_0^T U(C_t)\exp(-\rho t)dt + \int_S^R V\left(\mathcal{L}_t\right)\exp(-\rho t)dt + X(T-R), \tag{3}$$

with $U'(C_t) > 0, U''(C_t) < 0$, $V'(\mathcal{L}_t) > 0$, $V''(\mathcal{L}_t) < 0$, $X'(T-R) > 0$ and $X''(T-R) < 0$ where ρ is the subjective rate of time preference. These preferences simplify our analysis. The

[17] One should bear this qualifier in mind at our discussion of the model simulations. These simulations are only meant to stress the importance of various complementarities over the life-cycle and these complementarities are in our view relevant in both competitive and non-competitive labor markets.

costs of forgone labor time are measured by forgone labor earnings. The value of retirement leisure is governed by $X(T-R)$.[18]

The representative individual optimally decides the number of years S in education. $W(S)$ is the rental rate of human capital of type S. This rental rate is assumed to be constant over time and differs between individuals with different skill levels. $W(S)$ features positive but diminishing marginal returns of additional initial schooling: $W'(S) > 0$, $W''(S) < 0$. Alternatively, one may interpret $W(S)$ as the production function of human capital. The costs of education are the forgone earnings $W(S)$ while not working and the direct costs P per year of education (we ignore the utility or disutility of education). Without loss of generality, we keep the direct costs of education fixed. We assume here that the government can affect decision on the optimal years of schooling only through the tax system and education subsidies. In the real world, governments affect the education choices of individuals through a host of other mechanisms, for example, by outlawing child labor, by setting minimum school leaving ages, and so on. These alternative instruments can be regarded as implicit rather than explicit subsidies on education. As such, our model is still suited to capture the main incentive issues and we do not think that this undermines our main story of the various complementarities over the life-cycle. Nevertheless, some of these policies may require fewer public resources than education subsidies and could be preferred for that reason.

The individual starts his life with A_0 in financial assets which are normalized to zero for convenience ($A_0 = 0$). He borrows in a perfect capital market at constant real interest rate r to finance the costs of living and the costs of education in the periods when he is enrolled in initial education. The flow budget constraint of the individual while still in school ($t \leq S$) is therefore given by

$$\dot{A}_t = (1-\tau_A) r A_t - C_t - (1-s)P, \quad 0 \leq t \leq S, \tag{4}$$

where a dot denotes a time-derivative. Since $A_0 = 0$, and C_t and P are both positive, the individual accumulates debt in the first periods of his life. τ_A is the tax on interest income. Interest payments of education loans are deductible for the interest tax. s is the subsidy rate on direct educational costs.

After graduation, the individual starts earning gross labor income $W(S)H_tL_t$. 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 after graduation until retirement ($S < t \leq R$) state that the increase in financial assets should equal total interest income (which is negative when individuals repay debts), net labor income $(1-\tau_L)W(S)H_tL_t$ (where τ_L is

[18]The separability between leisure and retirement from consumption in the utility function avoids discontinuities in the marginal utility of consumption.

the labor income tax rate), minus consumption C_t:

$$\dot{A}_t = (1-\tau_A)rA_t + (1-\tau_L)W(S)H_tL_t - C_t, \quad S < t \leq R. \tag{5}$$

After retirement, until death ($R < t \leq T$), the representative individual does not work anymore and runs down his accumulated assets for consumption purposes:

$$\dot{A}_t = (1-\tau_A)rA_t + B - C_t, \quad R < t \leq T, \tag{6}$$

where B is the net retirement benefit in each year spent in retirement. One should interpret the pension benefit B 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: $A_T = 0$.

The representative individual can increase his human capital by allocating time I_t to learning activities, while foregoing labor earnings or leisure time. It's assumed that on-the-job training does not require direct costs. The individual has one unit of on-the-job human capital when he enters the labor market, i.e., $H_S \equiv 1$. On-the-job human capital accumulates according to a Ben-Porath (1967) type of production function

$$\dot{H}_t = G(S)F(I_t, H_t) - \delta H_t, \quad S < t \leq R, \tag{7}$$

where $F_I(I_t, H_t) > 0$, $F_H(I_t, H_t) > 0$, $F_{II}(I_t, H_t) < 0$, $F_{HH}(I_t, H_t) < 0$ and $F_{IH}(I_t, H_t) > 0$. $G(S)$ denotes the productivity of on-the-job-training, which increases with the initial level of education at a diminishing rate: $G'(S) > 0$ and $G''(S) < 0$. This captures the main idea of dynamic complementarity in skill-formation. Larger levels of initial education increase the productivity of investments in on-the-job training. Furthermore, there is dynamic complementarity in human capital formation on-the-job because the marginal product of training investments $G(S)F_I(I_t, H_t)$ increases with the level of human capital H_t as indicated by the positive cross-derivative $F_{IH}(I_t, H_t) > 0$. Larger levels of human capital increase the productivity of later human capital investments. δ denotes the rate of depreciation of human capital. Browning, Hansen, and Heckman (1999) survey empirical estimates of Ben-Porath earnings functions. Specification ((7)) is consistent with estimates reported by Heckman, Lochner, and Taber (1998).[19]

[19]Initial education is acquired in both families and schools. Our current formulation lumps human capital formation in families and schools together during the initial phase. However, human capital formation in schools and families are by no means perfect substitutes, see for example Cunha, Heckman, Lochner and Masterov (2006) for more on this. Investment in on-the-job human capital takes place mainly in firms. The

Integrating the asset accumulation constraints and imposing the initial and terminal conditions on financial wealth gives the life-time budget constraint of the individual

$$\begin{aligned} & \int_0^T C_t \exp(-r^* t)dt + \int_0^S (1-s)P \exp(-r^* t)dt \\ = & \int_S^R (1-\tau_L)W(S)H_t L_t \exp(-r^* t)dt + \int_R^T B \exp(-r^* t)dt, \end{aligned} \tag{8}$$

where $r^* \equiv (1-\tau_A)r$ is the net discount rate.

The individual maximizes life-time utility by choosing consumption, labor supply, leisure, on-the-job training, education, and retirement subject to the household budget constraint, the time constraints and the accumulation equation for on-the-job human capital. The appendix contains the derivation.[20]

Using standard results we obtain the Euler equation for consumption

$$\frac{\dot{C}_t}{C_t} = \theta_t \left(r^* - \rho\right), \quad 0 \leq t \leq T, \tag{9}$$

where $\theta_t \equiv \left(-\frac{U''(C_t)C_t}{U'(C_t)}\right)^{-1}$ is the inter-temporal 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 life-cycle. A larger intertemporal elasticity of substitution results in a stronger upward sloping consumption profile and a stronger sensitivity of savings with respect to after-tax returns.[21]

The labor supply equation is governed by the first order condition:

$$\frac{V'(\mathcal{L}_t)}{U'(C_t)} = (1-\tau_L)W(S)H_t, \quad S < t \leq R. \tag{10}$$

The marginal willingness to demand leisure time decreases with the net wage rate and increases with the level of taxation. The gross wage rate increases with education S and on-

degree of complementarity between human capital formation through schools/families and firms is captured by the productivity of learning in the on-the-job human capital production function.

[20] We assume that first-order conditions are necessary *and* sufficient. The latter condition is not necessarily fulfilled due to the feedbacks between labor supply and human capital accumulation. In order to guarantee an interior solution, elasticities of human capital decisions (schooling and training) and labor supply decisions (work effort, retirement) should not be too high. Otherwise higher investments in human capital (schooling and training) will boost labor supply (work effort and retirement), which, in turn, increases the return to human capital investments. This increases human capital investment and labor supply expands in a second round, which again increases human capital investments, etc. Only sufficiently strong decreasing returns in schooling and training and a sufficiently concave leisure and retirement sub-utility functions ensure an interior solution. We assume that these conditions are met. See Arrow and Kurz (1970), Blinder and Weiss (1976), and Heckman (1975) for discussions of sufficiency conditions.

[21] Browning, Hansen, and Heckman (1999) survey the estimates of θ_t obtained from micro and macro data.

the-job human capital H_t. Hence, better skilled workers supply more labor if the substitution effect dominates the income effect in labor supply (which is the empirically plausible case; see Browning, Hansen, and Heckman, 1999). Therefore, this equation implies that labor supply and skill formation are complementary activities. Indeed, the data previously discussed show that more highly educated workers have higher participation rates and lower unemployment rates.

The optimal number of years in initial education follows from the first-order conditions for education, leisure demand, labor supply and training[22]

$$\begin{aligned}&\int_S^R (1-\tau_L)W'(S)H_tL_t\exp(-r^*(t-S))dt + \frac{G'(S)}{G(S)}\frac{F(I_S,1)}{F_I(I_S,1)}(1-\tau_L)W(S)\\&= (1-s)P + (1-\tau_L)W(S)\left(L_S + \frac{\mathcal{L}_S}{\epsilon_S}\right),\end{aligned} \tag{11}$$

where $\epsilon_t \equiv \frac{V'(\mathcal{L}_t)\mathcal{L}_t}{V(\mathcal{L}_t)} > 0$ is the elasticity of the leisure sub-utility function at time t.

This is a modified Mincer equation stating that the net present value of marginal returns to initial education (evaluated at the time of graduation S) should be equal to net marginal costs on additional year of schooling. The latter comprise direct, subsidized expenditures and net forgone labor earnings. Years spent in initial education increase when the returns to human capital investments are larger. This is the case when the working life is longer and individuals retire later (R larger). We note here that the returns at later ages are more heavily discounted, so that expanding the retirement age has only small effects when the discount rate is sufficiently large. The feedback between retirement and education may gain in strength due to training on-the-job. On-the-job training becomes more profitable when individuals retire later, (see below), and this in turn enhances initial investment in education. Returns increase when individuals invest more in on-the-job training during their working lives (H_t larger) and supply more labor (L_t larger). The standard Mincer equation ignores the interaction with labor supply and training on-the-job. In addition, the time horizon is finite and direct costs of education are not negligible as also noted by Heckman, Lochner and Todd (2006).[23] Furthermore, individuals with a higher level of education have a larger return on investments in on-the-job human capital as indicated by $\frac{G'(S)}{G(S)}\frac{F(I_S,1)}{F_I(I_S,1)}(1-\tau_L)W(S)$

[22]Note that $H_S \equiv 1$, since individuals do not train if they are not in the labor market yet.

[23]The term $L_S + \frac{\mathcal{L}_S}{\epsilon_S}$ originates from the fact that more time spent on initial education lowers the time-span over which labor can be supplied or leisure can be consumed, see the utility function. L_S is associated with the marginal loss of forgone labor earnings, and $\frac{\mathcal{L}_S}{\epsilon_S}$ is associated with marginal forgone leisure time when individuals invest more time in initial education. In the absence of endogenous leisure demand during working-life, $\mathcal{L}_S = 0$, and $L_S + \frac{\mathcal{L}_S}{\epsilon_S}$ equals $(1 - I_S)$. The same is true if the sub-utility function over leisure $V(\mathcal{L}_S)$ is linear, i.e., when $\epsilon_S = 1$. In that case, more time spent in initial education reduces the marginal value of working and leisure time during working life equally.

which denotes the discounted value of larger human capital investments in training due to more initial education.

All these results underscore the second important complementarity. Educational investments increase when the utilization of human capital is larger and when skills are better maintained through on-the-job training. Initial schooling is therefore complementary to later retirement, hours worked and on-the-job training. Again, this is in conformity with the data presented earlier.

Labor taxation directly reduces investments in initial education as long as the subsidy rate is smaller than the tax rate ($\tau_L > s$). If the subsidy rate s equals the tax rate on labor τ_L taxation is neutral with respect to human capital investments because then all costs and benefits of human capital formation are symmetrically affected by the tax and subsidy rates. Capital income taxation (as reflected in a lower r^*) boosts initial education. The reason is that higher capital income taxation lowers the net discount rate at which marginal benefits of education are discounted. Alternatively, one can say that higher taxes on capital income induce substitution in household life-time asset portfolio's from financial towards human assets (see Heckman, 1976). Labor taxation nevertheless reduces labor supply and lower the retirement age (shown below), hence labor taxation still discourages investments in initial education by lowering the utilization rate of human capital.

Optimal retirement is given by

$$\frac{X'(T-R)}{\lambda_R} = (1-\tau_L)W(S)H_R\left((1-\varrho)L_R + \frac{1-L_R}{\epsilon_R}\right), \tag{12}$$

where $\lambda_t \equiv U'(C_0)\exp(-r^*t)$ is the marginal value of income at time t, and $\varrho \equiv \frac{B}{(1-\tau_L)W(S)H_RL_R}$ is the implicit marginal tax rate on additional years of work due to the presence of (early) retirement incomes.[24] 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 net the forgone labor earnings in the last year on the labor market.[25]

[24]Note that $I_R = 0$ at the end of the working life.

[25]Again, there is a term $(1-\varrho)L_R + \frac{1-L_R}{\epsilon_R}$ representing the impact of retirement on the time-span over which individuals enjoy labor earnings and ordinary leisure. $(1-\varrho)L_R$ corresponds with the marginal loss of forgone labor earnings, which are reduced one-for-one with the implicit tax on retirement due to actuarially unfair pensions. $\frac{1-L_R}{\epsilon_R}$ measures the marginal value of forgone leisure time when individuals retire earlier. In the absence of an endogenous leisure demand decision and actuarially fair pensions ($L_R = 1$ and $\varrho = 0$) this term would vanish. Similarly, the last term cancels out if the leisure sub-utility function $V(\mathcal{L}_R)$ is linear ($\epsilon_R = 1$), and pensions are actuarially fair ($\varrho = 0$). Later retirement then augments the marginal value of working and leisure time equally.

The individual has stronger incentives to retire later if the individual has more initial education S, has accumulated a higher stock of on-the-job human capital H_R, and supplies more labor effort L_R in the retirement year R. The labor tax directly distorts retirement decisions, because retirement utility is not taxed, whereas continued work is. This direct impact of labor taxation on retirement is not often discussed in the literature on retirement (e.g. Gruber and Wise, 1999). Indeed, this literature mainly focuses on the implicit marginal tax rate on additional years of work, ϱ, due to the presence of actuarially unfair (early) retirement incomes. The implicit tax ϱ on continued work exacerbates the impact of the labor tax τ_L on the decision to exit the labor market. $\lambda_R \equiv U'(C_0)\exp(-r^*R)$ captures wealth effects in the retirement decision. Richer individuals, with a lower marginal utility of income, retire earlier – ceteris paribus. The third complementarity is therefore that retirement is delayed when individuals utilize and maintain their skills better through working life. Hence, more skilled workers retire later when the income effect of higher skills are outweighed by the substitution effects of higher skills. Again, this is in conformity with the data.

Investment in on-the-job training is governed by the following equation

$$\frac{\mu_t}{\lambda_t} G(S) F_I(I_t, H_t) = (1-\tau_L) W(S) H_t, \tag{13}$$

where $\frac{\mu_t}{\lambda_t}$ is the shadow value – expressed in monetary units – of one unit of human capital at time t. This equation states that the marginal costs of on-the-job human capital investment (right-hand side) should be equal to the discounted value of marginal benefits in terms of higher wages (left-hand side). The benefits and costs of OJT investments increase when schooling levels are higher and when the individual has a higher stock of human capital. The benefits also increase when the shadow value $\frac{\mu_t}{\lambda_t}$ of human capital is large. Now we see that higher levels of initial education both increase the opportunity costs of training on-the-job and the marginal benefits of training on the job. The same holds for a higher stock of on-the-job human capital.

We assume that $F(I_t, H_t) \equiv [\Phi(I_t, H_t)]^{\phi}$, where $0 < \phi < 1$ and $\sigma \equiv \frac{\Phi_I(I_t,H_t)\Phi_H(I_t,H_t)}{\Phi_{IH}(I_t,H_t)\Phi(I_t,H_t)}$. ϕ is a returns to scale parameter and σ is the elasticity of substitution between I and H in the homothetic constant returns to scale sub-production function $\Phi(I_t, H_t)$. We then find an arbitrage equation between on-the-job human capital investments and financial saving:

$$\begin{aligned} &G(S)F_H(I_t,H_t) + G(S)\frac{F_I(I_t,H_t)L_t}{H_t} + \\ &\left(1 - \frac{\omega_H}{\sigma} + (1-\phi)\,\omega_H\right)\frac{\dot{H}_t}{H_t} + \left(\frac{\omega_H}{\sigma} + (1-\phi)(1-\omega_H)\right)\frac{\dot{I}_t}{I_t} = r^* + \delta, \end{aligned} \tag{14}$$

where $\omega_H \equiv \frac{\Phi_H(I_t,H_t)H_t}{\Phi(I_t,H_t)}$.[26] The left-hand-side gives the total returns of one extra unit of human capital. The right-hand-side gives the required rate of return on investments in OJT; the net returns on financial savings plus the rate of depreciation.

The fourth complementarity in skill formation follows from the last equation. First, individuals with more initial education S will engage in more on-the-job training because the productivity of OJT investments is enhanced by higher initial education. This is again in conformity with the data; more educated workers engage more in training. Second, if labor supply increases and human capital is more heavily utilized, the marginal returns to investments in on-the-job training increase. Therefore, individuals who work more hours or participate more in the labor market have higher returns on training. Third, if individuals maintain their skills though their working career, later investments in human capital become more profitable. σ measures the dynamic complementarity of on-the-job human capital investments. If $\sigma = 0$, it is not possible to remedy neglect of on-the-job training in the early years of the working career. Early and late investments are perfect complements. If $\sigma > 0$ it is to some extent possible to remedy poor skill maintenance early in working careers. If $\sigma = \infty$ initial and later investments are perfect substitutes. ω_H then measures the plasticity of investments in human capital. If $\omega_H > 1/2$ plasticity is smaller at later ages than at early ages. If ω_H is close to 1 it may be very costly to remediate deficient early career investment in on-the-job training. When $\omega_H = 1$, it is impossible.[27]

The tax rate on labor incomes is absent in the training arbitrage equation. Linear income taxes affect marginal costs and benefits of training equally and therefore do not directly reduce training investment.[28] Note, however, that labor supply and retirement are distorted by higher taxes. So taxes do indirectly affect the returns to training by lowering the marginal benefits as the utilization rate of the stock of on-the-job human capital falls and the payback-time of investments decreases. Capital income taxes boost training by lowering the required rate of return on training investments. Intuitively, a higher capital income tax increases the net present value of additional labor earnings resulting from larger training efforts.

4.2 Policy impacts

In general, explicit analytical solutions to the model can be found only if one imposes (strong) functional form restrictions on preferences or technologies. To illustrate some of the important interactions described in the previous section, we present some numerical simulations of the model where it is either assumed that OJT-investments are fixed ($H_t \equiv 1$, $I_t \equiv 0$)

[26] Ben-Porath (1967) is a special case of the current model.

[27] This analysis mirrors those of Cunha and Heckman (2007) and Heckman (2007).

[28] Note that direct costs of training are absent.

and labor supply, initial investment and retirement are endogenous, or where training and retirement are endogenous, but labor supply and initial investment in human capital are fixed (i.e, $L_t \equiv 1$, and $S =$ constant).

In the simulations, the uncompensated labor supply elasticity is set at 0.18 (if endogenous), the uncompensated retirement elasticity is set at 0.2, and the elasticities of the human capital production function are based on findings from the literature. The baseline policy variables are $\tau_L = 0.5$, $s = 0.75$, and $\varrho = 0.3$. These values match (unweighted) averages for the sample of 16 continental European and Anglo-Saxon countries we analyzed in Section 2. 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, 2007a). 79% is the average of subsidies on higher education, which probably corresponds better to a marginal subsidy than the average subsidy on all levels of education (OECD, 2007b). Gruber and Wise (1999), OECD (2004c), and Duval (2004) show that the implicit tax on work after age 55 amounts to around 30% for an older worker aged between 55–65, although there are substantial cross-country differences.[29] In order to abstract from various complications in determining effective marginal tax rates on capital income, we set capital income taxes to zero in the simulations ($\tau_A = 0$).[30] None of our conclusions depend on this particular assumption. Jacobs (2009a) and Jacobs (2009b) provide more details on the calibration of the models and provide extensive sensitivity analyses.

Figure 24 plots the simulated life-cycle labor supply patterns for various policy experiments for the model where investments in OJT are fixed throughout the life-cycle. Each panel shows that individuals are enrolled in initial education for the first years of their life-cycle, then labor is supplied during working life, and the final years of life are spent in retirement. The time path of labor supply during working lives is downward sloping over the life-cycle due to income effects as the consumption profile rises with age (not shown). In the baseline simulation, labor supply at the end of the life cycle is around 60%. If labor supply is interpreted as the employment rate, the downward sloping path matches falling labor force participation rates over the life cycle quite well (OECD, 2006a). All figures show that various decisions over the life-cycle are affected by policy.

[29]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 (2004c) 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%.

[30]Good measures of marginal effective tax rates on savings are difficult to obtain as institutional details are crucial. Taxes on savings may easily be shifted to labor (consumption) which we cannot account for since we use a partial equilibrium setup. And, corporate income taxes play a role as well in determining the effective tax burden on savings. See, for example, Carey and Rabesona (2004).

As expected, panel A of Figure 24 shows that higher labor taxes result in less education, lower labor supply and earlier retirement. The model yields an uncompensated wage elasticity of labor supply of approximately 0.18, which is not extreme. Although taxes directly distort labor supply, human capital investment and retirement, life-cycle interactions between labor supply and human capital decisions reinforce the impact of taxes. As a result, very substantial declines in labor supply, retirement ages and years of education are found as labor taxes increase. Indeed, the uncompensated elasticity of the tax base is 0.46, which more than twice as large as the simple labor supply elasticity (Jacobs, 2009a). Panel B of Figure 24 shows the impact of education policy. This graph most clearly illustrates the importance of the dynamic interactions over the life-cycle. The subsidy only directly increases human capital investments, not labor supply and retirement. However, higher education subsidies indirectly boost labor supply and the retirement age as individuals become better educated. The costs of leisure and retirement increase with the level of human capital and quite strong effects of higher education subsidies on labor supply and retirement decisions are found in the simulations. Similarly, a larger retirement wedge also shows that human capital investments and retirement decisions are interacting, see panel C of Figure 24. A lower retirement wedge directly results in later retirement and indirectly also in larger investment in human capital. The effects are not very large because returns to education at later points in the life-cycle are heavily discounted. Labor supply responds marginally to a lower retirement wedge. Substitution effects in wages – due to a higher education level – are relatively small and income effects – due to a longer working life – are relatively large. Both effects roughly cancel out.

Life-cycle interactions only gain in importance when on-the-job training is allowed to be endogenous. Jacobs (2009b) analyzes a model with exogenous labor supply and initial investment in human capital (i.e, $L_t \equiv 1$, and $S =$ constant), but with endogenous retirement and OJT. Figure 25 plots the effects of labor taxes and retirement policies on investments in OJT, retirement ages, and lifetime earnings profiles. Labor earnings drop to zero at the retirement age. Investment in OJT is high at the beginning of the working career, and declines until the retirement age is reached. The reason is that the payback-time of investments continuously decreases. The life-cycle profile of labor earnings steadily increases until it peaks 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 life-cycle in the absence of depreciation of human capital. Labor productivity (not shown) peaks before earnings, since individuals are still investing some of their time endowment in OJT at the peak in labor productivity, cf. Ben-Porath (1967) and Heckman (1976). The individual also has a valuable time endowment

after retirement, although it is steadily depreciating over time. Investment in human capital drops to zero at retirement, since the marginal value of investment in human capital has become zero then.

Life-cycle investments in OJT are affected by the labor tax. However, the labor tax impacts human capital investments only indirectly, since all costs of OJT are deductible and labor supply is exogenous. A higher (explicit) tax on retirement reduces OJT-investments to a considerable extent, since the payback period of investment in human capital falls. Since retirement is distorted by the presence of the positive implicit tax on retirement, the effect is substantial. Consequently, life-cycle earnings profiles shift towards the origin, and earnings peak earlier. Since less time will be invested in OJT, earnings when young increase slightly. However, lower growth of human capital stocks implies that earnings at later ages will be (much) lower. This, in turn, promotes earlier retirement as the opportunity costs of retirement decrease if wages are lower. A higher implicit tax on retirement gives similar results as a higher labor tax, since it also gives stronger incentives to retire early. As a result, investment in human capital declines at all ages. Since less human capital will be accumulated, workers end up with lower wages at the end of their careers and they retire earlier. Thus, actuarially very unfair retirement schemes seriously impair investments in OJT over the life-cycle. This finding 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.

The model simulations clearly demonstrate that the policy environment is very important to understand life-cycle interactions between education, labor supply, OJT, and retirement. Human capital formation, labor supply, investment in OJT, and later retirement are complementary. In panel D of Figure 24 we have simulated the model with exogenous OJT with a set of policy parameters that correspond with the unweighted averages of the policies of Anglo-Saxon, Continental European, Mediterranean and Nordic countries, see also Section 2. We can infer from these simulations that America's labor supply is larger than in Europe due to the high marginal taxes on work effort in Europe. Moreover, the main driver behind the earlier retirement of Europeans is the larger total tax wedge on retirement. Early retirement in turn depresses skill maintenance in OJT and lowers wage growth over the life-cycle. The simulations illustrate that human capital policy in Europe reduces implicit taxes on skill formation created by various welfare state arrangements. Indeed, many European countries subsidize initial education much more than the US, especially in the Nordic countries. Without subsidies on skill formation, explicit and implicit taxes on human capital formation would generate more dependence on welfare states as skill formation, skill utilization, and skill maintenance would be retarded. In other words, there is not only a trade-off between equity and efficiency in the quantity of labor supply, but also a trade-off between equity and

the quality of labor supply.

5 Conclusions

European welfare states that attempt to protect incomes and labor market prospects for persons with low skills face important policy challenges. Labor demand has shifted towards the skilled workers as can be witnessed from increasing earnings inequality and the rising returns to education. The growth in the supply of human capital is likely to choke off in years to come. Despite increasing enrollment rates at higher levels of education, resources invested in Europe remain rather stagnant at all levels (except for the Nordic countries) and often more targeted on higher education than pre-school and primary education. A substantial fraction of immigrant youths have literacy problems, drop out from secondary education, do not assimilate and end up disproportionally in crime or welfare state arrangements. Poverty traps not only result in weak incentives to work, but also in weak incentives to invest in human capital. As relative demand for unskilled labor decreases, low skill workers become increasingly dependent on welfare state arrangements such as unemployment benefits, public training and labor market policies. In the end, social cohesion could be undermined with a growing divide on labor markets between the skilled and the unskilled and a larger dependency of low skill workers on welfare state arrangements.

European welfare states do not only affect skill creation, but also Europe's skill utilization is low for a variety of reasons. Hours worked are low and decreasing. Labor force participation rates are relatively low – especially in Continental Europe and Mediterranean countries – but increasing which is in part due to larger female participation rates. Take up rates of benefits for unemployment, sickness, and disability are very substantial. Many unemployed workers appear to be hidden in generally ineffective active labor market and training policies. Generous social benefits and high levels of taxation lower labor force participation and hours worked and thereby lower returns on human capital investments. Generous welfare states create substantial implicit taxes on the returns to human capital investments through the interaction with the labor market.

Not only is the utilization rate of European human capital low, also the maintenance of human capital is worrisome. Effective retirement ages have fallen dramatically and have landed on a low plateau in recent years. Declining labor force participation rates of older workers are showing signs of a trend reversal in some countries (after controlling for the increase in female labor force participation rates). Individuals spend about one third of their life-time in retirement. Incentives to retire long before statutory retirement ages are strong due to generous pension and early retirement schemes. Short payback times of investments

in human capital and steep depreciation rates of skills undermine the incentives to create and maintain skills through education and on-the-job training.

Human capital policies can be both efficient and equitable and can thus be helpful to maintain welfare states. Human capital investment is self-productive and investments at different ages are complementary. Self-productivity and complementarity are the reasons why skill begets skill and learning begets learning. Complementarity implies that early investments need to be followed by later investments if the early investments are to pay off. The returns to human capital of children are very high and rising, hence larger investments are efficient. Moreover, there is no trade-off between equity and efficiency at early ages of human development, but a substantial trade-off at later ages. Once skills are crystallized, complementarity implies that the returns are highest for investment in the most able. At the youngest ages, it is possible to form ability and create the stock of skills that enrich late adolescent and early adult human capital investment. Thus, early interventions targeted toward the disadvantaged can be very efficient. Later investments are not.

Policies that focus heavily on early childhood interventions for children from disadvantaged families are effective. At later ages policies are generally too costly and ineffective. Given public spending constraints, it is efficient to shift resources away from higher education to pre-school and primary education, while private funding for higher education can expand, possibly through income contingent loans to warrant access. The benefits of labor market and training programmes for older workers are doubtful and the costs are high. Successful policies focus on both noncognitive and cognitive skills. The benefits of lower crime rates and socially more acceptable behavior are substantial. Family policy can be effective. Early cognitive and noncognitive deficits can be partially remedied.

Dynamic complementarities are not only important for initial investments in life, but also for the utilization and the maintenance of skills during working life. Returns to investments early in life will not materialize if early investments are not followed up by later investments. A precondition for sufficient returns to investments during working life is a sufficient level of investment early in life. The returns of European human capital investments are affected by tax-benefit and pension systems and the functioning of labor markets. European labor markets are distorted due to severe labor market regulations, high taxes, generous benefit schemes and insider-outsider problems in wage setting institutions. Stricter eligibility for various types of benefits and less income redistribution from the outsiders towards the insiders through all kinds of benefit schemes boosts labor supply and employment. This is both efficient and equitable, since the outsiders on labor markets are hurt by the privileged insiders. Reducing distortions in labor markets increases the utilization rates of human capital and enlarges the benefits of initial education and skill maintenance over the life-cycle. Retirement

is heavily subsidized via early retirement schemes and pension subsidies. These policies create perverse incentives to utilize and maintain human capital over the life-cycle. Therefore, actuarially fairer early-retirement schemes and pension plans can have beneficial incentive effects on the utilization and maintenance of skills over the life-cycle.

Appendix

The Hamiltonian for maximizing life-time utility is given by

$$\begin{aligned}\mathcal{H} &\equiv \int_0^T U(C_t)\exp(-\rho t)dt + \int_S^R V\left(\mathcal{L}_t\right)\exp(-\rho t)dt + X(T-R) \\ &+ \lambda\left[\int_S^R (1-\tau_L)W(S)H_tL_t\exp(-r^*t)dt + \int_R^T B\exp(-r^*t)dt\right] \\ &- \lambda\left[\int_0^T C_t\exp(-r^*t)dt + \int_0^S (1-s)P\exp(-r^*t)dt\right] \\ &+ \mu_t\left[G(S)F(I_t,H_t) - \delta H_t\right] + \nu_t\left[1-L_t-I_t-\mathcal{L}_t\right],\end{aligned} \tag{15}$$

where λ is the marginal utility of life-time income, μ_t is the co-state variable at time t associated with the on-the-job human capital accumulation equation, and ν_t is the shadow value of the time-constraint at time t.

First-order conditions for a maximum are given by

$$\frac{\partial\mathcal{H}}{\partial C_t} = U'(C_t)\exp(-\rho t) - \lambda\exp(-r^*t) = 0, \qquad 0\leq t\leq T, \tag{16}$$

$$\frac{\partial\mathcal{H}}{\partial\mathcal{L}_t} = V'(\mathcal{L}_t)\exp(-\rho t) - \nu_t = 0, \qquad S<t<R, \tag{17}$$

$$\frac{\partial\mathcal{H}}{\partial L_t} = \lambda(1-\tau_L)W(S)H_t\exp(-r^*t) - \nu_t = 0, \qquad S<t<R, \tag{18}$$

$$\begin{aligned}\frac{\partial\mathcal{H}}{\partial S} &= -V(\mathcal{L}_S)\exp\left(-\rho S\right) - \lambda(1-s)P\exp(-r^*S) \\ &- \lambda(1-\tau_L)W(S)H_SL_S\exp(-r^*S) \\ &+ \lambda\int_S^R (1-\tau_L)W'(S)H_tL_t\exp(-r^*t)dt + \mu_S G'(S)F(I_S,H_S) = 0,\end{aligned} \tag{19}$$

$$\begin{aligned}\frac{\partial\mathcal{H}}{\partial R} &= V(\mathcal{L}_R)\exp\left(-\rho R\right) - X'(T-R) \\ &+ \lambda\left((1-\tau_L)W(S)H_RL_R - B\right)\exp(-r^*R) = 0,\end{aligned} \tag{20}$$

$$\frac{\partial \mathcal{H}}{\partial I_t} = \mu_t G(S) F_I(I_t, H_t) - \nu_t = 0, \quad S < t < R, \tag{21}$$

$$\begin{aligned} \frac{\partial \mathcal{H}}{\partial H_t} &= \lambda(1-\tau_L) W(S) L_t \exp(-r^* t) \\ &+ \mu_t \left[G(S) F_H(I_t, H_t) - \delta \right] = -\dot{\mu}_t. \quad S < t < R, \end{aligned} \tag{22}$$

In addition, we have to impose a transversality condition on the co-state variable that $\mu_R = 0$.

The equations in the main text are derived as follows. Note that $\lambda = U'(C_0)$ from the first-order condition for C_0. Totally differentiating the first-order condition for C_t with respect to time gives the Euler equation for consumption in equation (9). Combining the first-order conditions for C_t, L_t, and $\mathcal{L}_t$ yields equation (10). Equation (13) can be found by substituting the first-order condition for L_t into the first-order condition for I_t. To derive equation (11), we obtain from the first-order conditions for L_t and $\mathcal{L}_t$:

$$\frac{V(\mathcal{L}_t)}{\lambda_t} \exp(-\rho t) = \frac{1}{\epsilon_t} (1-\tau_L) W(S) H_t \mathcal{L}_t, \tag{23}$$

where $\lambda_t \equiv U'(C_0) \exp(-r^* t)$, and $\epsilon_t \equiv \frac{V'(\mathcal{L}_t)\mathcal{L}_t}{V(\mathcal{L}_t)}$. Substituting (13) and (23) in the first-order condition for S and using $H_S \equiv 1$ yields equation (11). Similarly, substitute (23) in the retirement equation to find (12). Finally, totally differentiate equation (13) to find

$$-\frac{\dot{\mu}_t}{\mu_t} = \frac{F_{II} I_t}{F_I} \frac{\dot{I}_t}{I_t} + \left(\frac{F_{IH} H_t}{F_I} - 1 \right) \frac{\dot{H}_t}{H_t} + r^*. \tag{24}$$

Substitute this result and equation (13) in the first-order condition for H_t:

$$G(S) F_H(I_t, H_t) + \frac{G(S) F_I(I_t, H_t) L_t}{H_t} - \frac{F_{II} I_t}{F_I} \frac{\dot{I}_t}{I_t} + \left(1 - \frac{F_{IH} H_t}{F_I} \right) \frac{\dot{H}_t}{H_t} = r^* + \delta. \tag{25}$$

Homogeneous functions of degree ϕ have the property that its partial derivatives are homogeneous of degree $\phi - 1$. Consequently, we can substitute $F_{II} I_t = (\phi - 1) F_I - F_{IH} H_t$ into the last equation:

$$\begin{aligned} &G(S) F_H(I_t, H_t) + \frac{G(S) F_I(I_t, H_t) L_t}{H_t} \\ &+ \left(1 - \phi + \frac{F_{IH} F}{F_I F_H} \frac{F_H H_t}{F} \right) \frac{\dot{I}_t}{I_t} + \left(1 - \frac{F_{IH} F}{F_I F_H} \frac{F_H H_t}{F} \right) \frac{\dot{H}_t}{H_t} = r^* + \delta. \end{aligned} \tag{26}$$

We assume that $F(I_t, H_t) \equiv [\Phi(I_t, H_t)]^\phi$, which has the following derivatives: $F_I = \phi \Phi^{\phi-1} \Phi_I$, $F_H = \phi \Phi^{\phi-1} \Phi_H$, $F_{IH} = \phi \Phi^{\phi-1} \Phi_{IH} (1 + (\phi - 1)\sigma)$. Therefore, we find $\frac{F_H H}{F} = \phi \omega_H$ and

$\frac{F_{IH}F}{F_I F_H} = \frac{1+(\phi-1)\sigma}{\phi\sigma}$. Substitution of these results yields equation (14).

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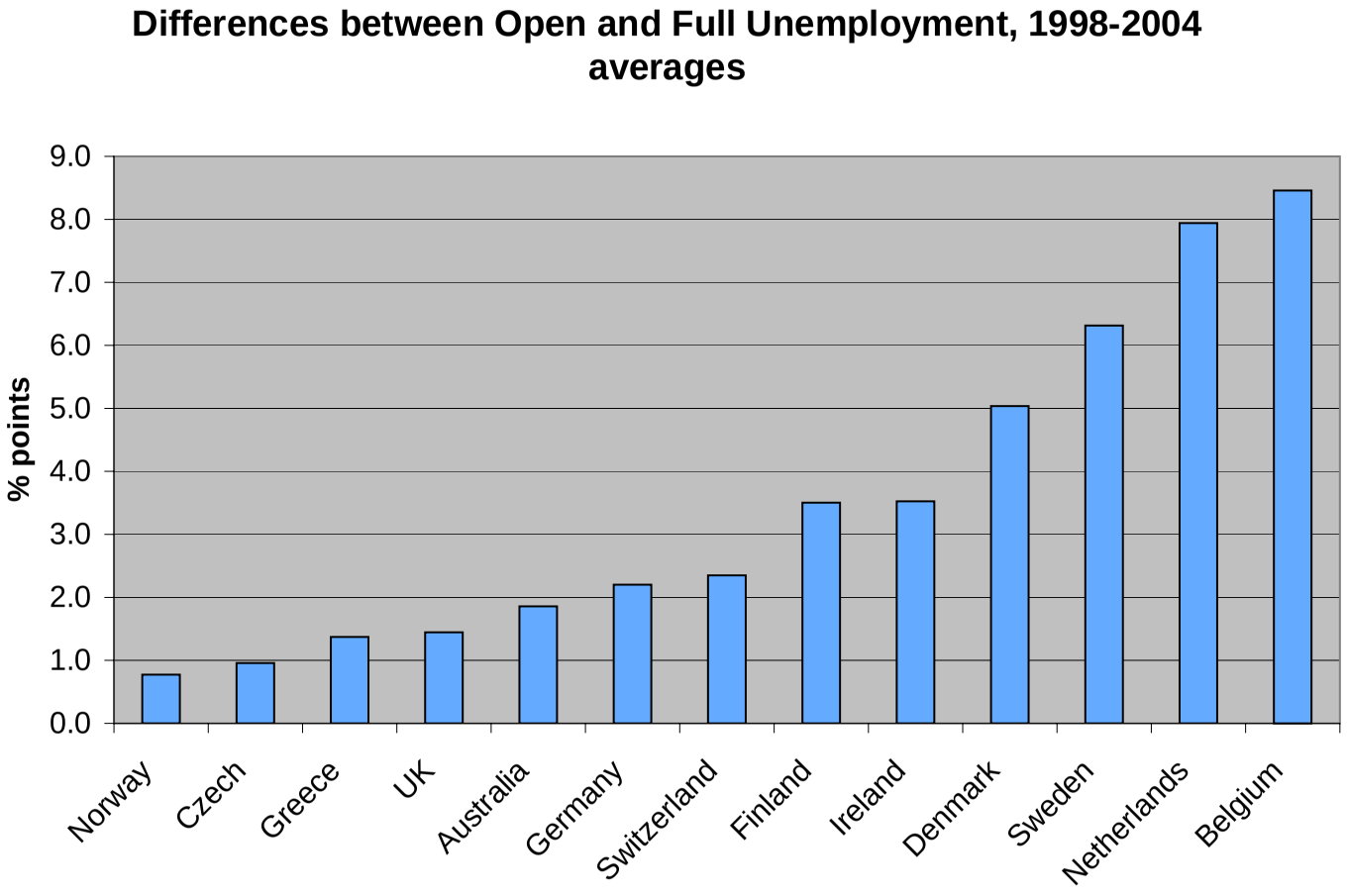
Figure 1: Hidden unemployment in ALMP



Key: The graph shows the difference between the true ('full') unemployment rate and the reported ('open') unemployment rate due to disguising unemployed persons as trainees.
Source: Heckman, Ljunge and Ragan (2006).

Figure 2: Inequality and higher educational attainment

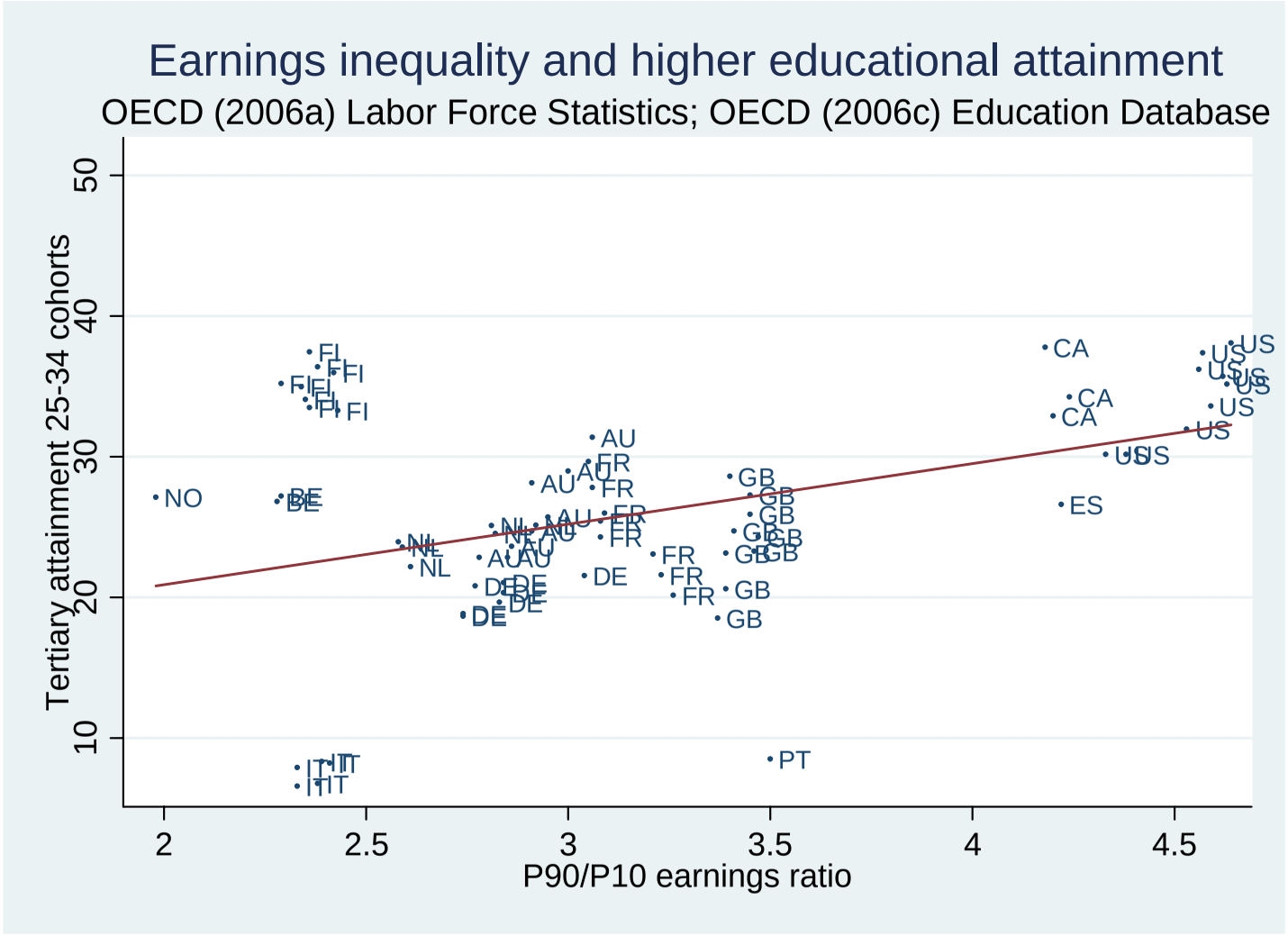
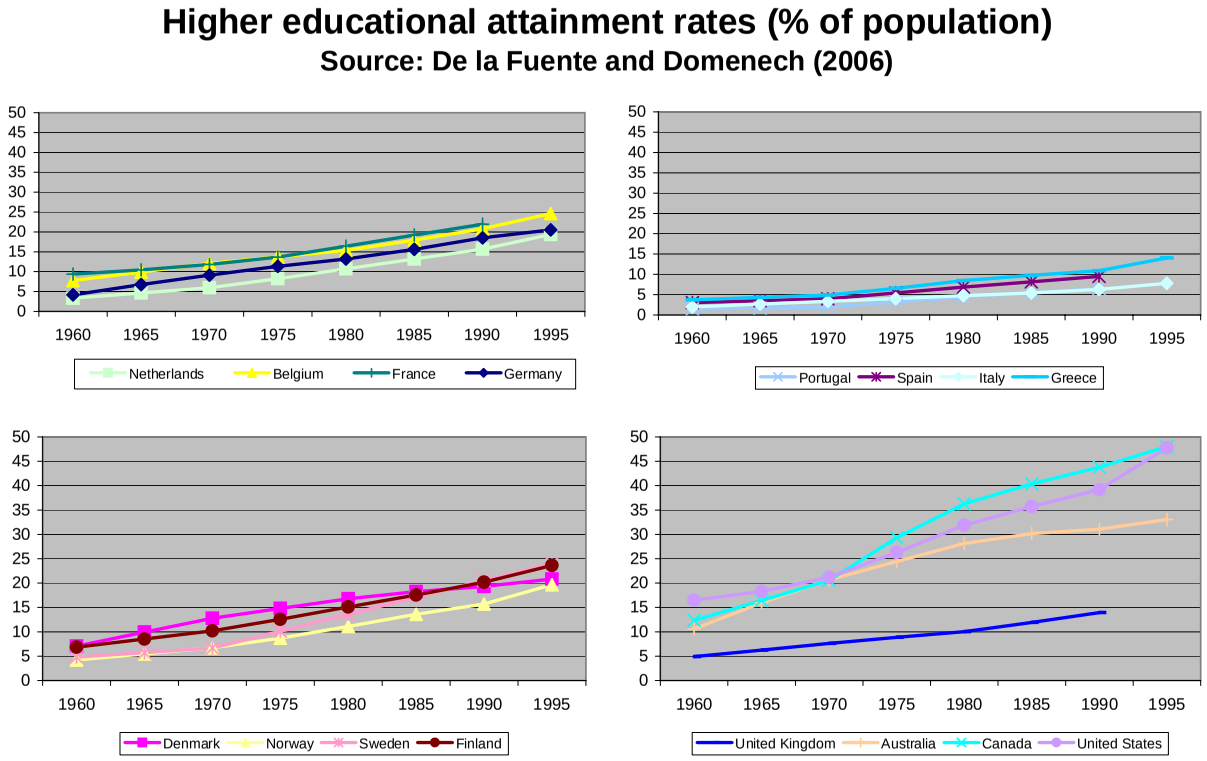


Figure 3: Attainment rates higher education across countries over time



Source: De la Fuente and Domenech (2006).

Figure 4: Growth in years of education and initial levels of education

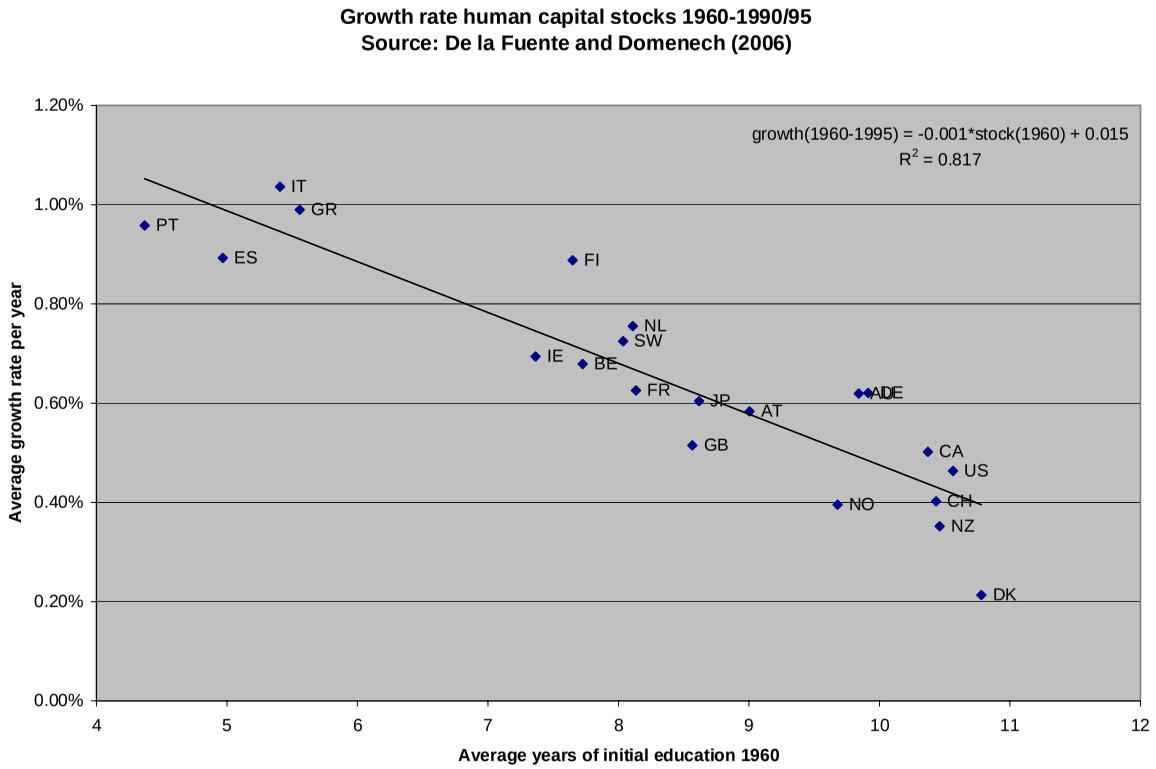


Figure 5: Change in total resources invested in primary, secondary and tertiary education across countries over time

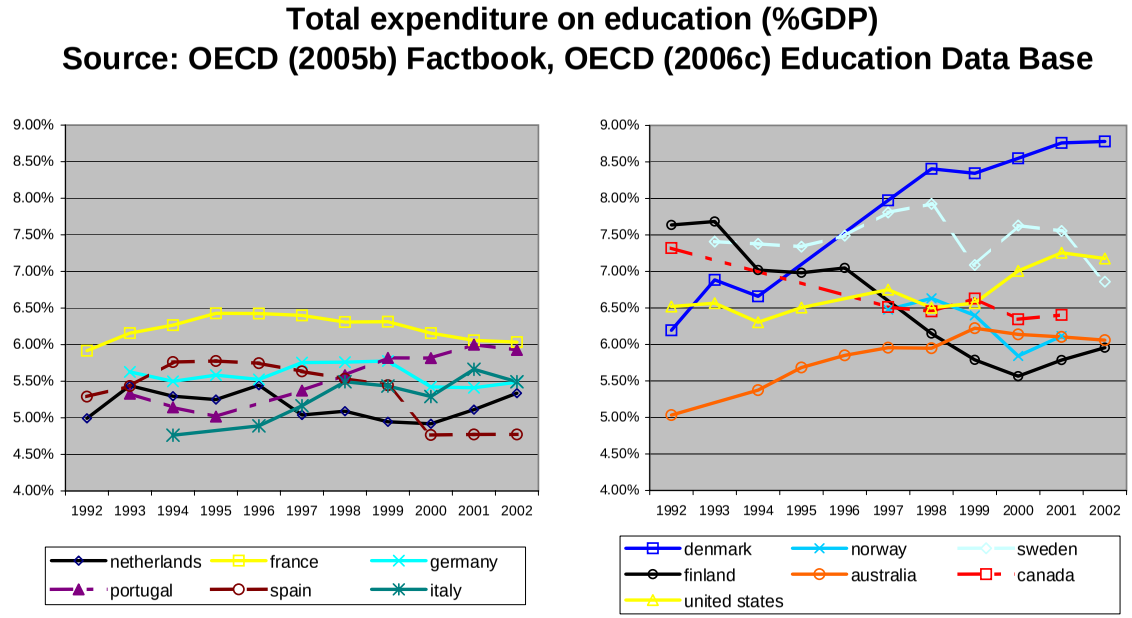


Figure 6: Share of private funding in education across countries

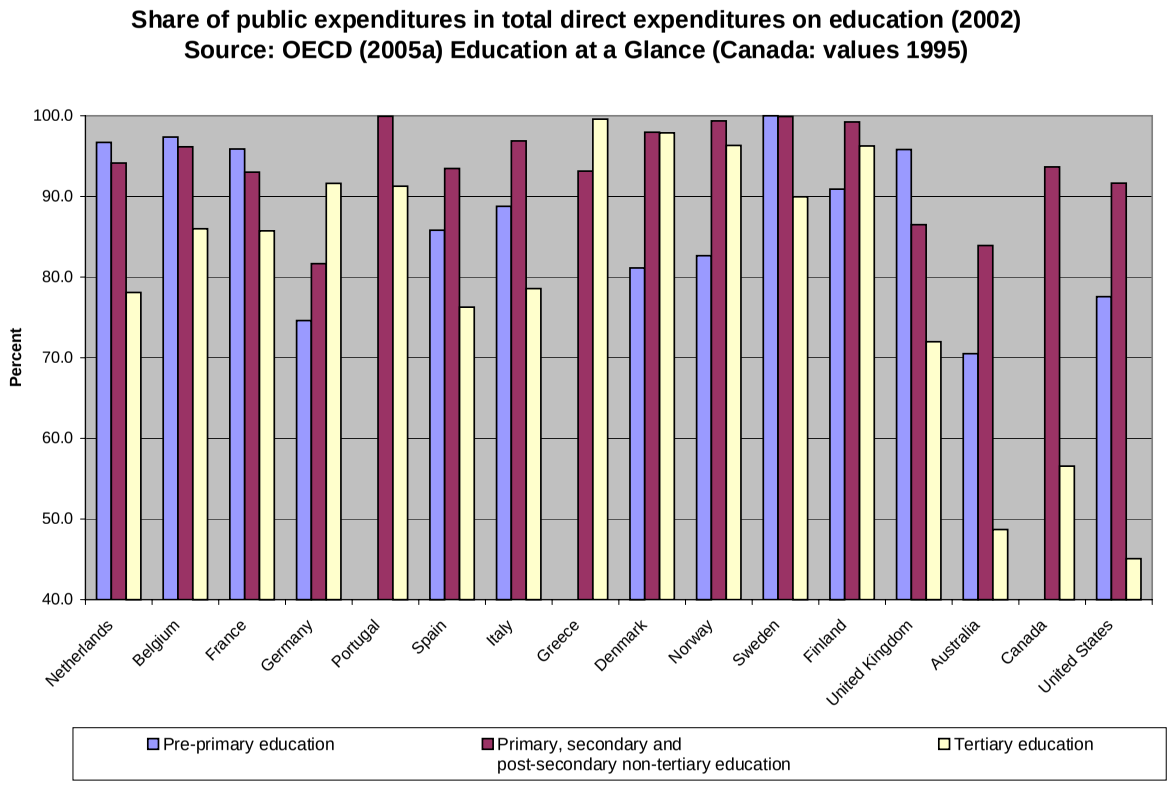
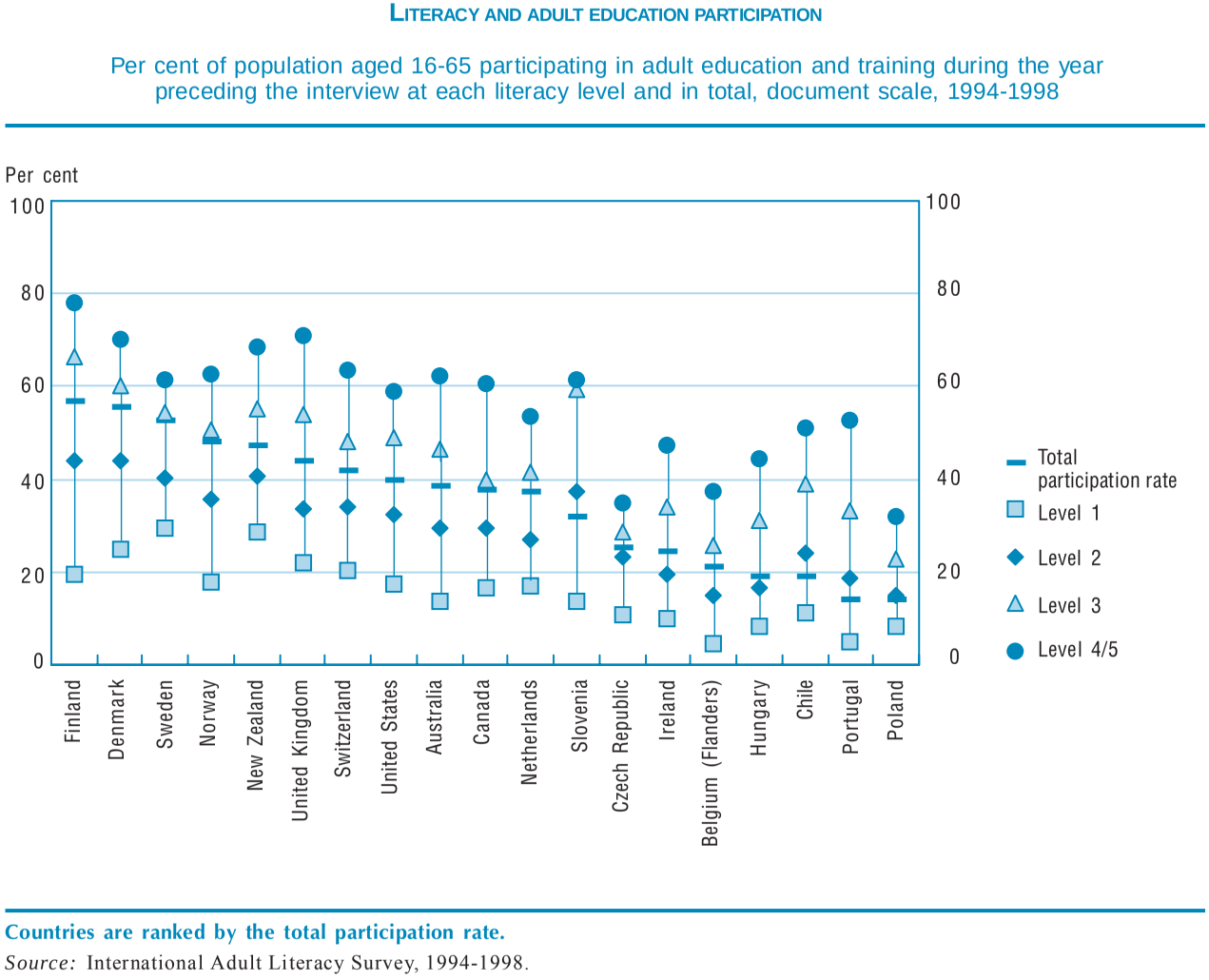


Figure 7: Training by education level across countries



Note: Document literacy measures the knowledge and skills required to locate and use information contained in various formats, including job applications, payroll forms, transportation schedules, maps, tables and graphics. Training is measured as enrollment in some form of organized adult education or training during the year preceding the interview.
Source: OECD (2003).

Figure 8: Spending on labor market programs across countries

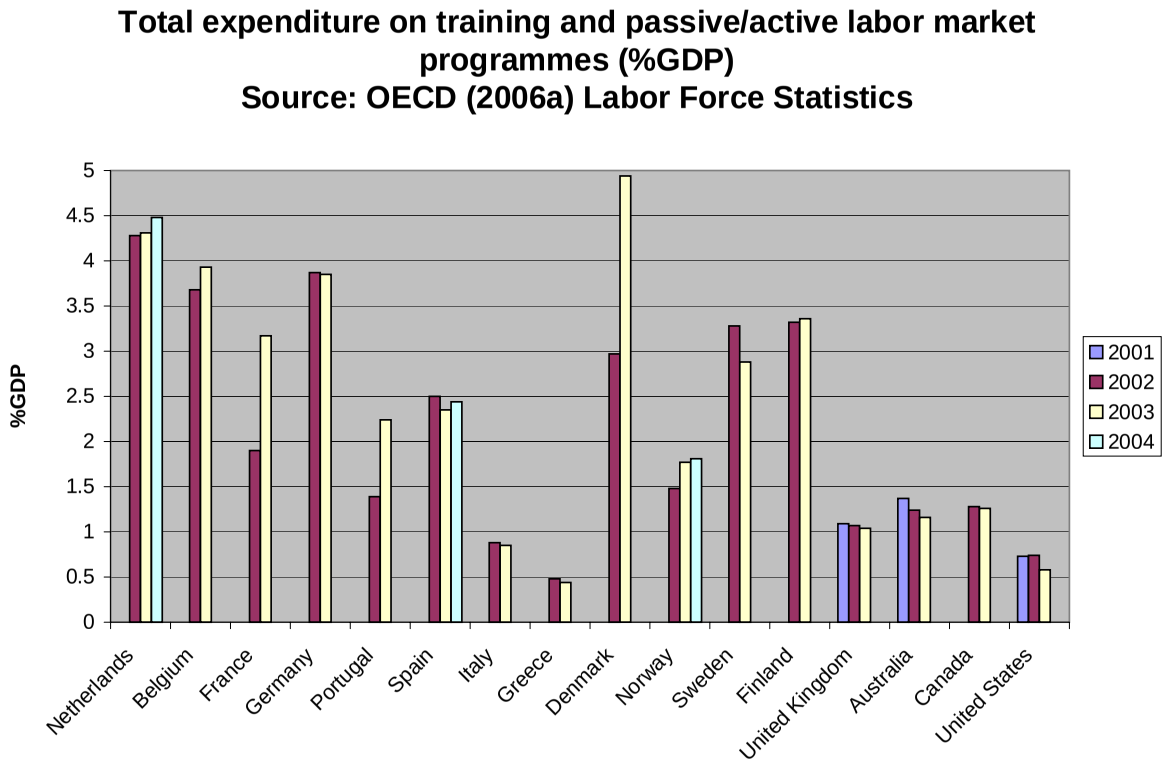


Figure 9: Labor productivity growth

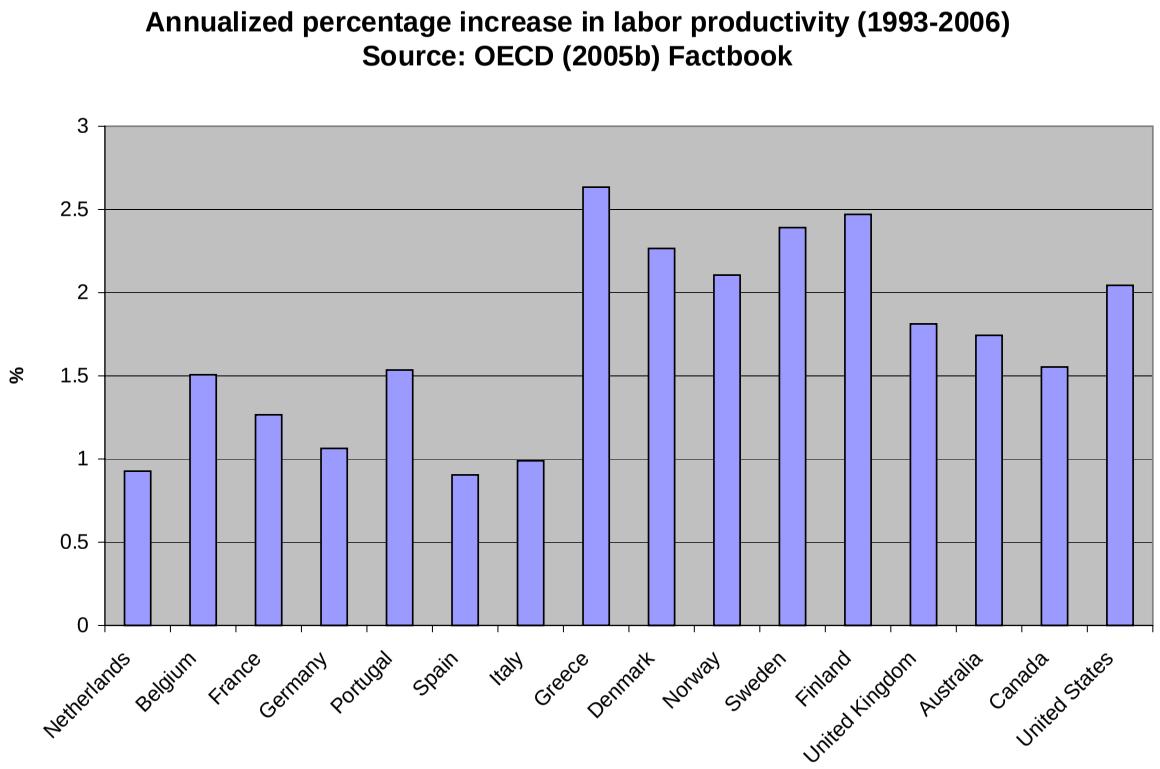


Figure 10: Labor force participation rates across countries over time

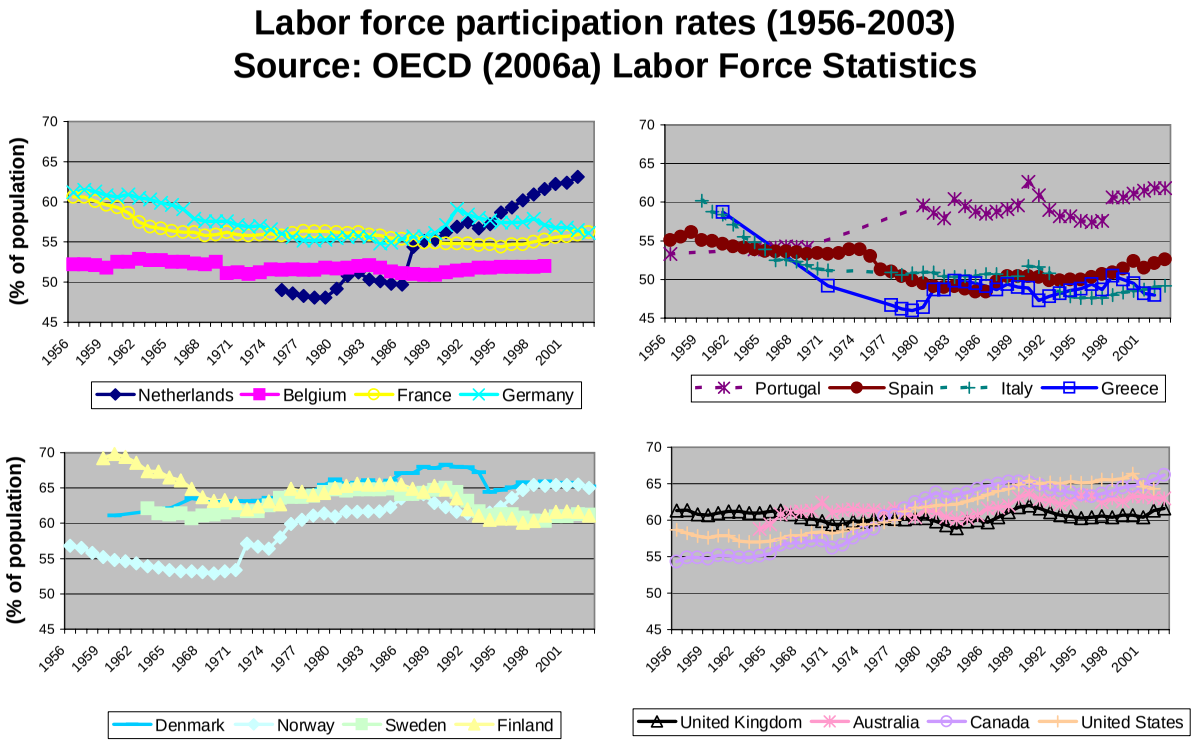


Figure 11: Participation rates by level of education across countries

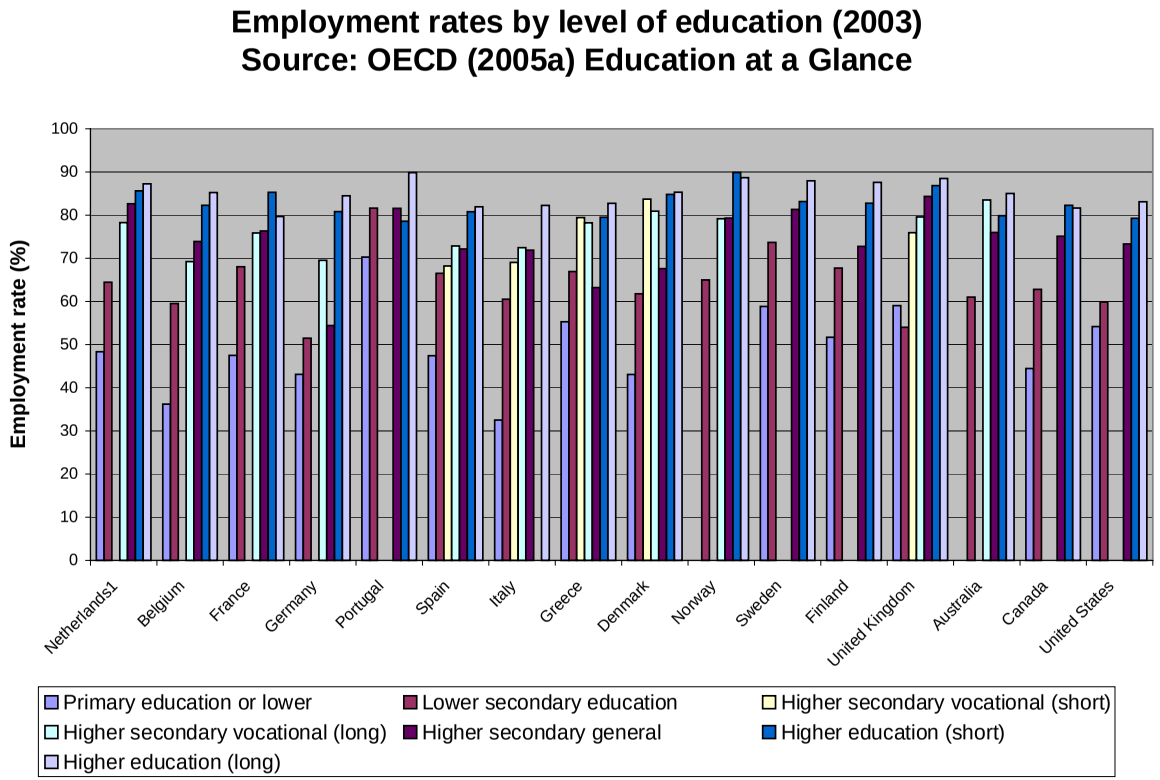


Figure 12: Non-employed disabled and sick workers across countries

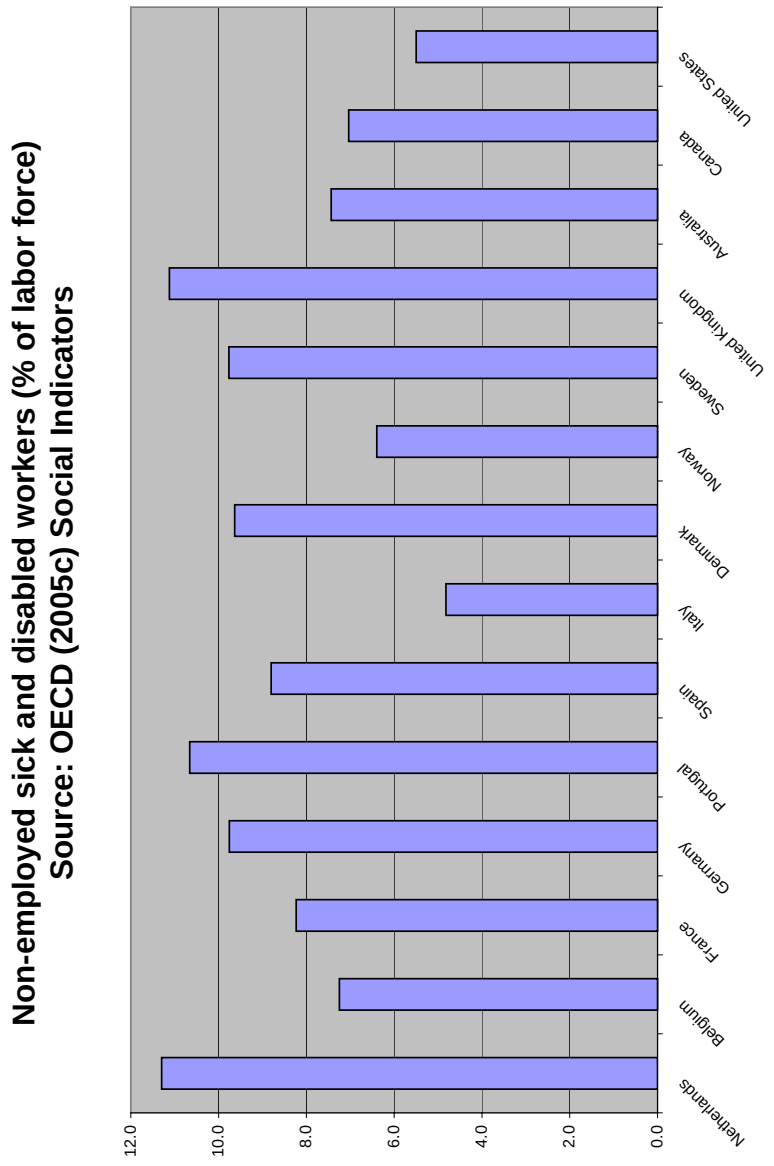


Figure 13: Replacement rates unemployed workers on average during 60 month period in unemployment across countries over time

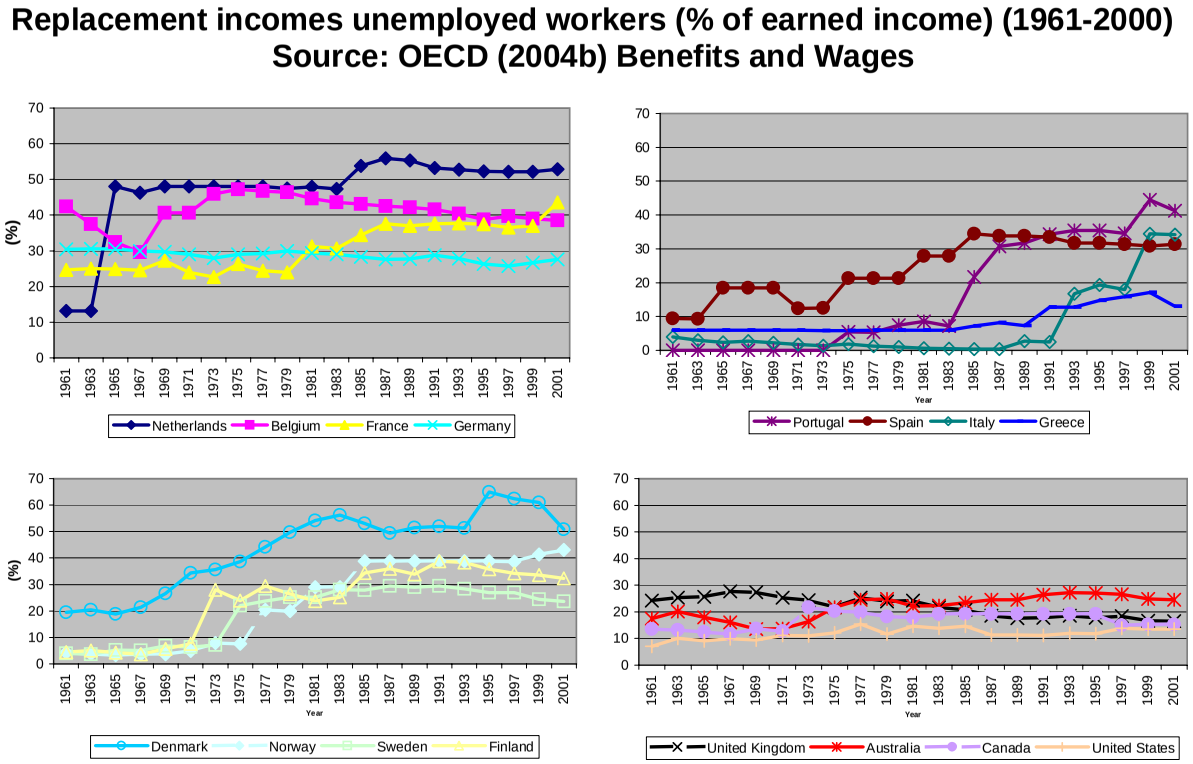
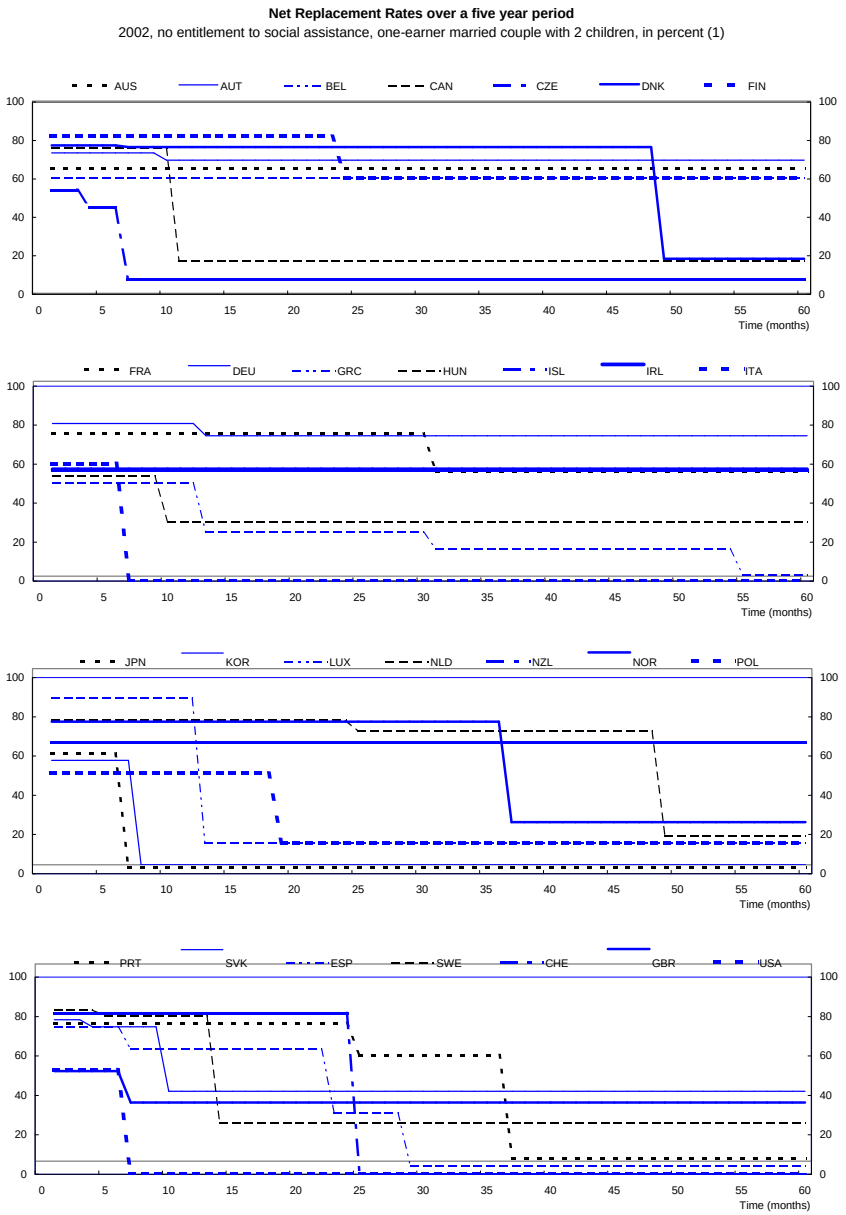


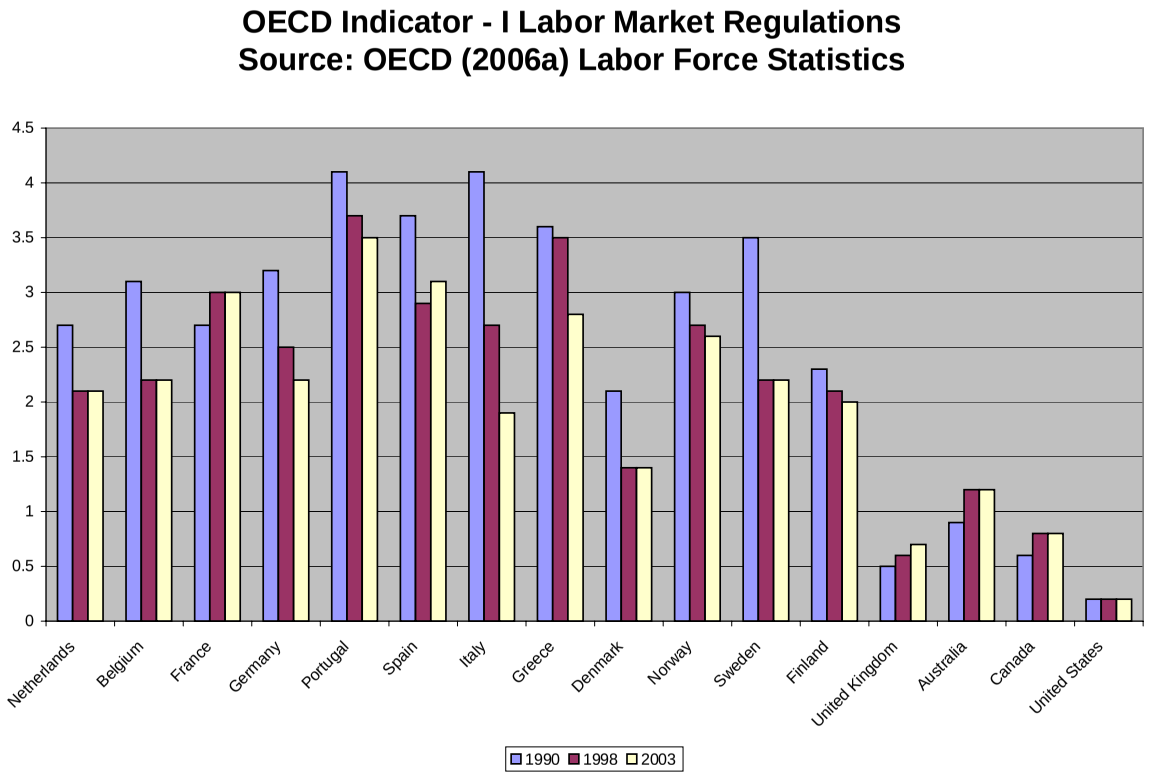
Figure 14: Development of eligibility to replacement incomes over 60-month period across countries



1. Month one refers to the first month of benefit receipt, *i.e.* following any waiting period. Previous in-work earnings are equal to APW. Children are aged 4 and 6 and neither childcare benefits nor childcare costs are considered.
Source: OECD, 2004, Benefits and Wages: OECD Indicators. www.oecd.org/els/social/workincentives

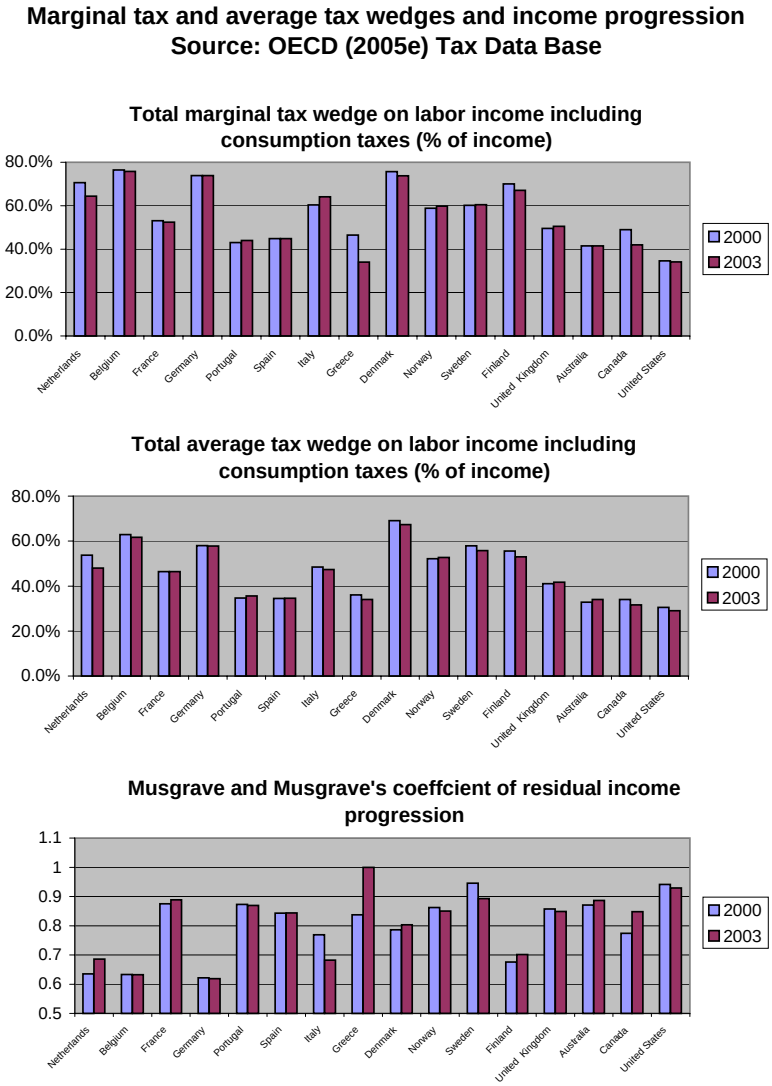
Source: OECD (2004b).

Figure 15: Severity of labor market regulations across countries over time



Note: The indicator measures the stringency of national legislation on employment protection (EPL) which are a cardinal summary of a set of indicators converted to cardinal scores and normalized to range from 0 to 6, with higher scores representing stricter regulation. Included are indicators for individual dismissals for regular employment, temporary employment, collective dismissals, regular procedural inconveniences, notice and severance pay for dismissals by tenure categories, difficulty of dismissal for regular contracts, legislation on fixed-term contracts, temporary work agency contracts, the definition of collective dismissal, additional notification requirements, additional delays involved, and other special costs to employers.

Figure 16: Taxation across OECD countries over time



Notes: All tax rates apply to a single worker earning the average production wage without children. For the US no consumption tax data were available. We assumed a US-consumption tax of 5%.

Figure 17: Labor force attachment older workers across countries

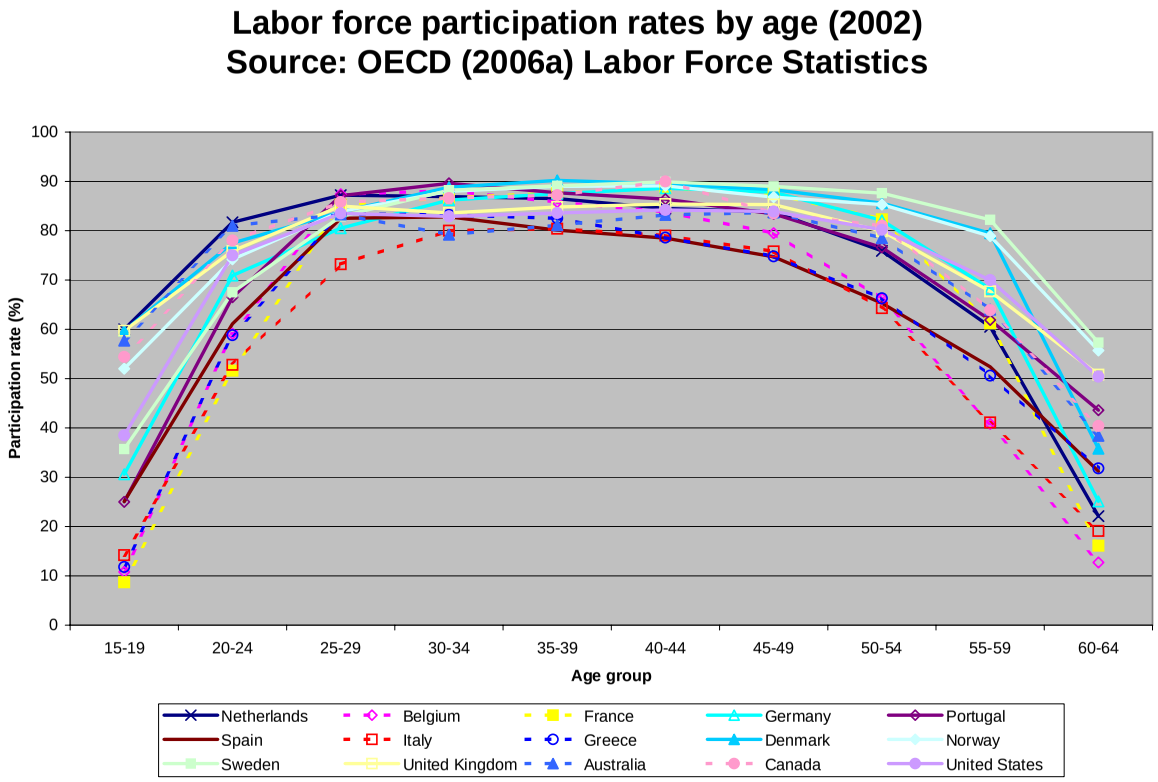
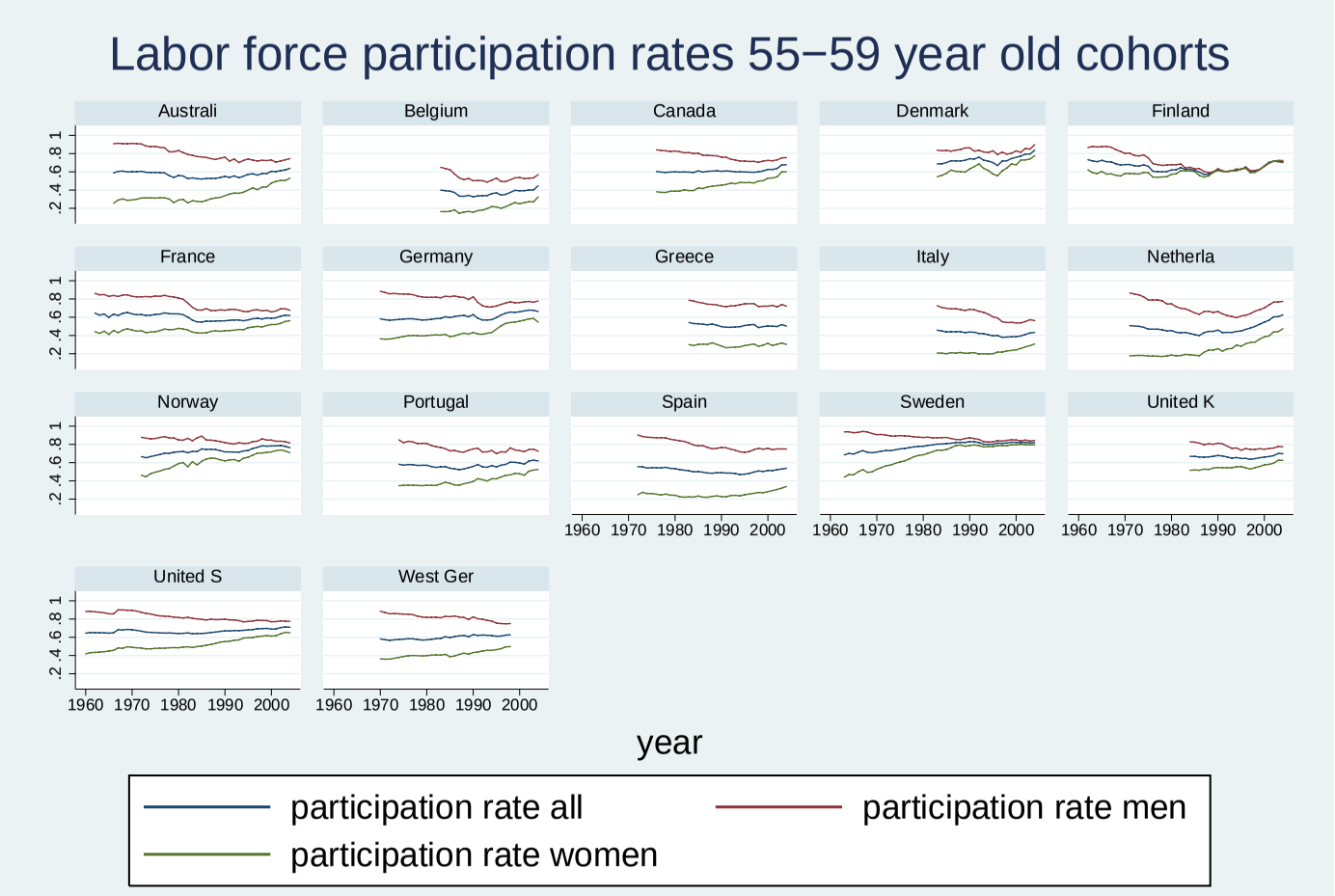


Figure 18: Labor force participation 55-59 year older workers across countries over time



Source: OECD (2006a) Labor Force Statistics

Figure 19: Development retirement age across countries over time

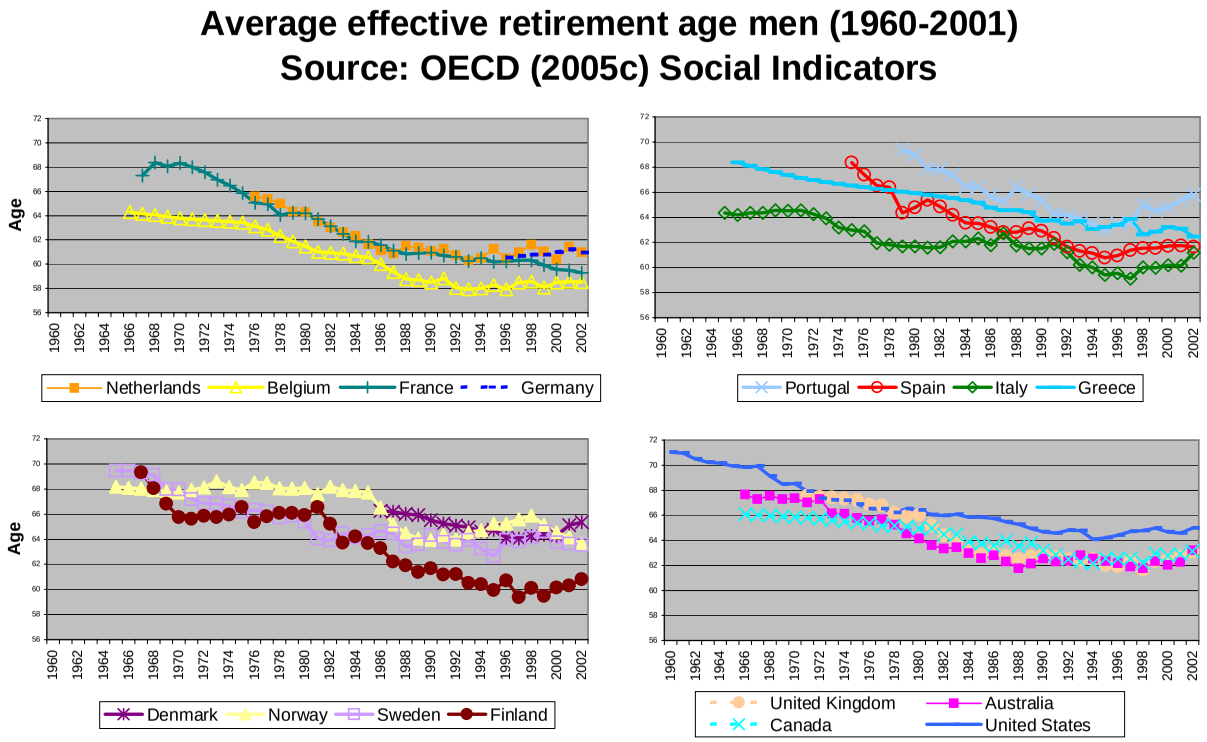
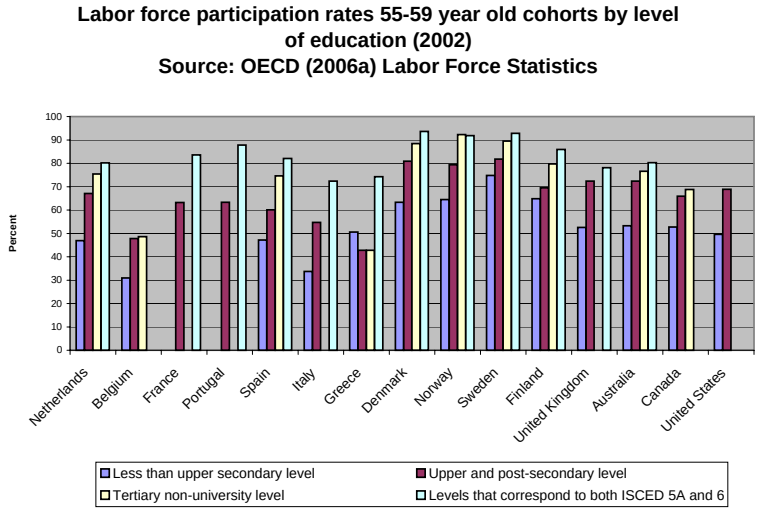


Figure 20: Labor force participation older workers and education level across countries



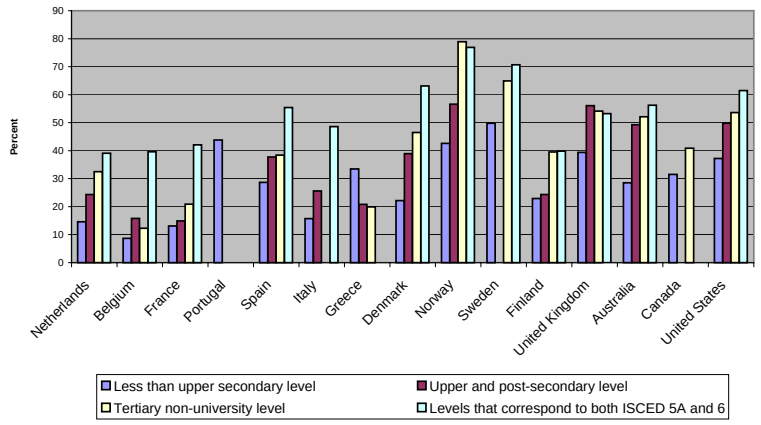


Figure 21: Pension benefits as a fraction of pre-retirement earnings across countries

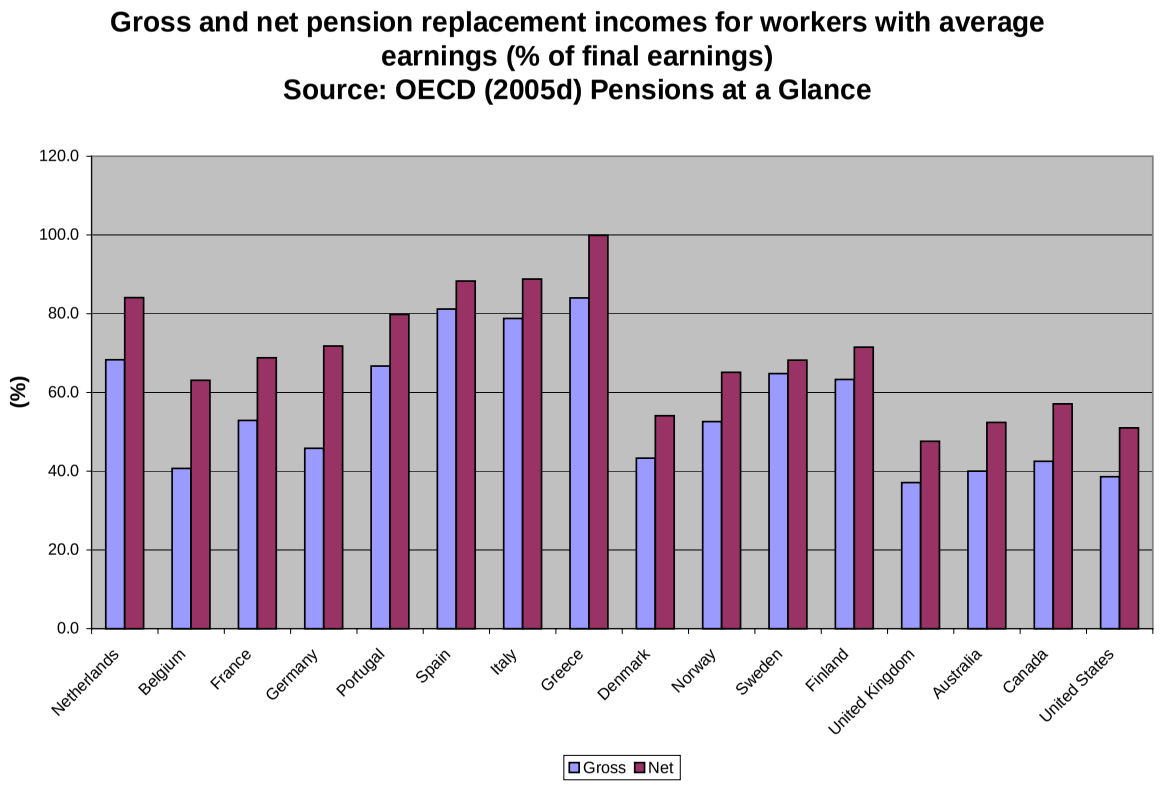
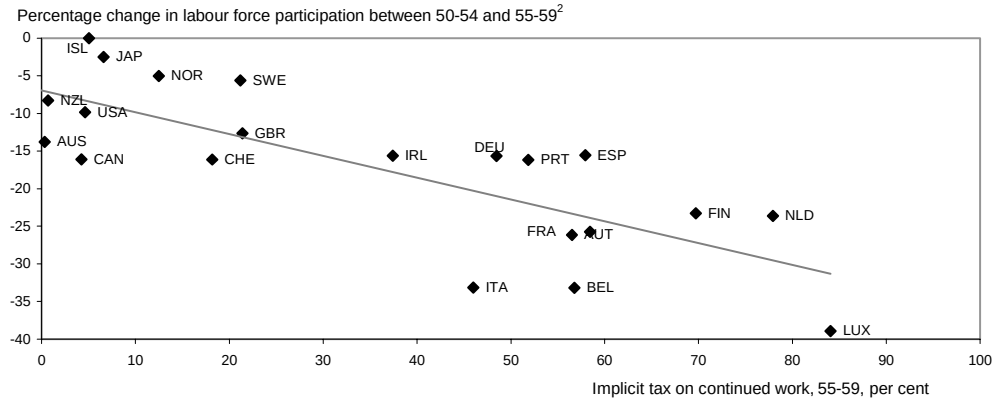


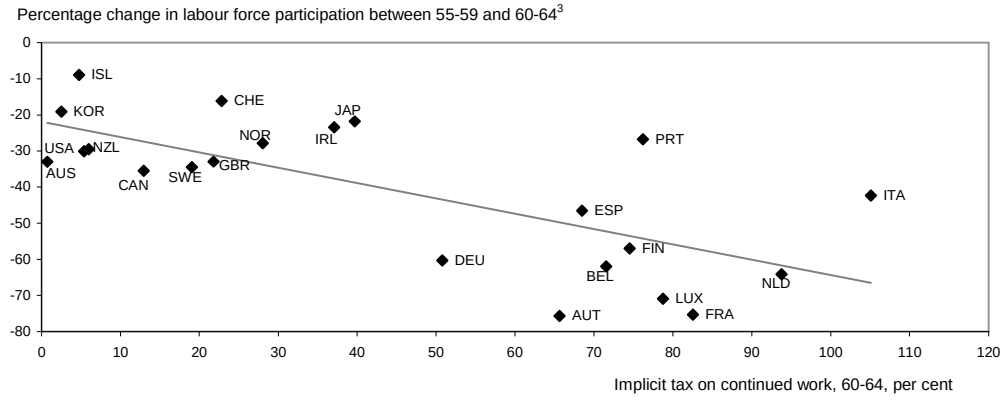
Figure 22: Implicit tax rates (pre-)retirement schemes across countries

Fall in male labour participation between two consecutive age groups and implicit tax rates on continued work, 1999 [1]

Panel A.



Panel B.

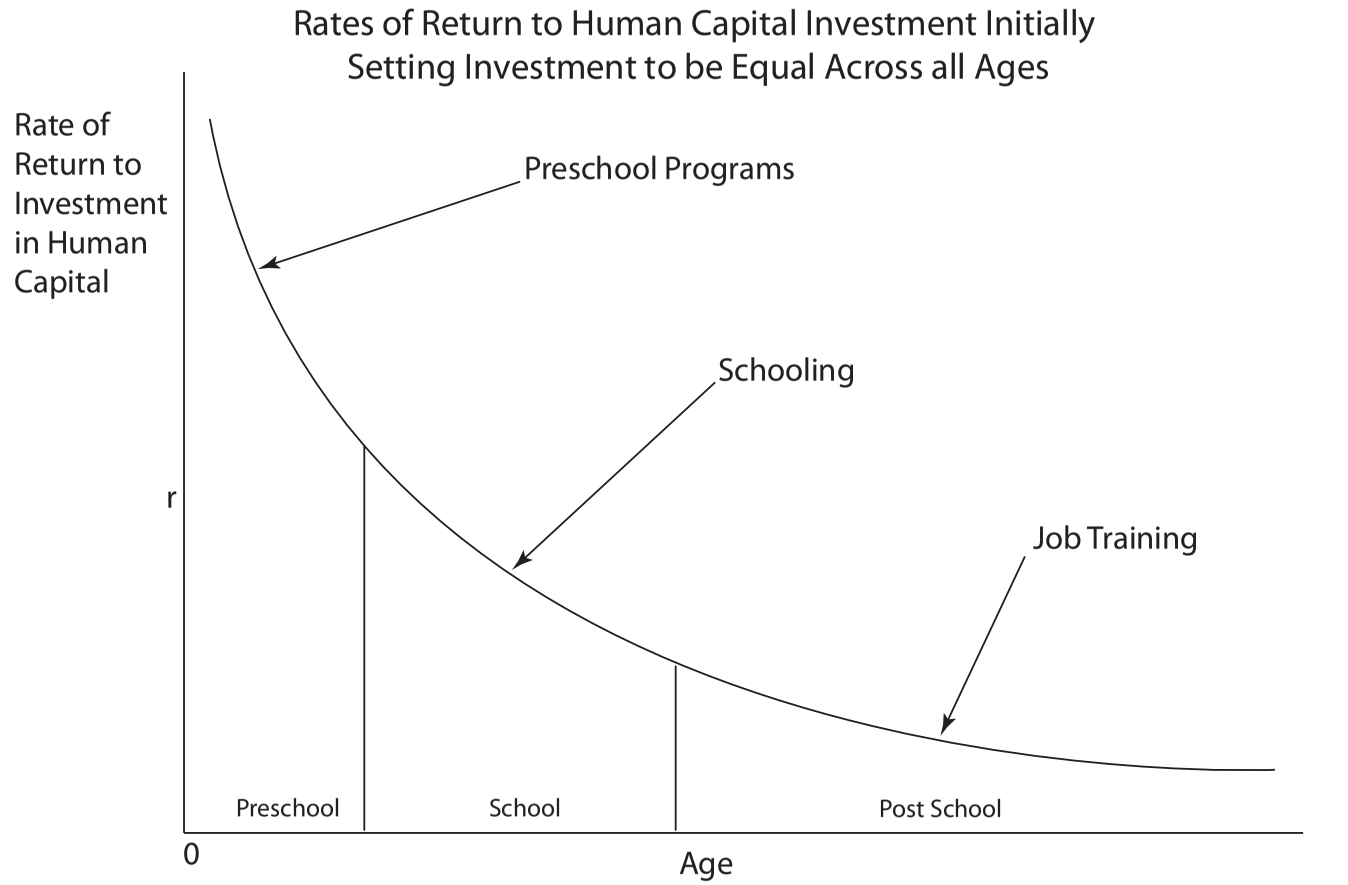


1. Implicit tax rates are calculated for a single worker with average earnings in 1999. In some cases, the results differ from those presented in Figure 4, which refer to currently legislated systems. These differences reflect either policy changes that took place after 1999 (e.g. Finland, France) or the future implementation of measures that were already legislated but had not yet come into effect in 1999 (e.g. the future maturation of the Superannuation Guarantee Scheme in Australia, the transition from the "old" to the "new" pension sytem in Italy).
2. (Pr55-59 - Pr50-54) / Pr50-54, per cent.
3. (Pr60-64 - Pr55-59) / Pr55-59, per cent.

Source: OECD.

Source: OECD (2004c).

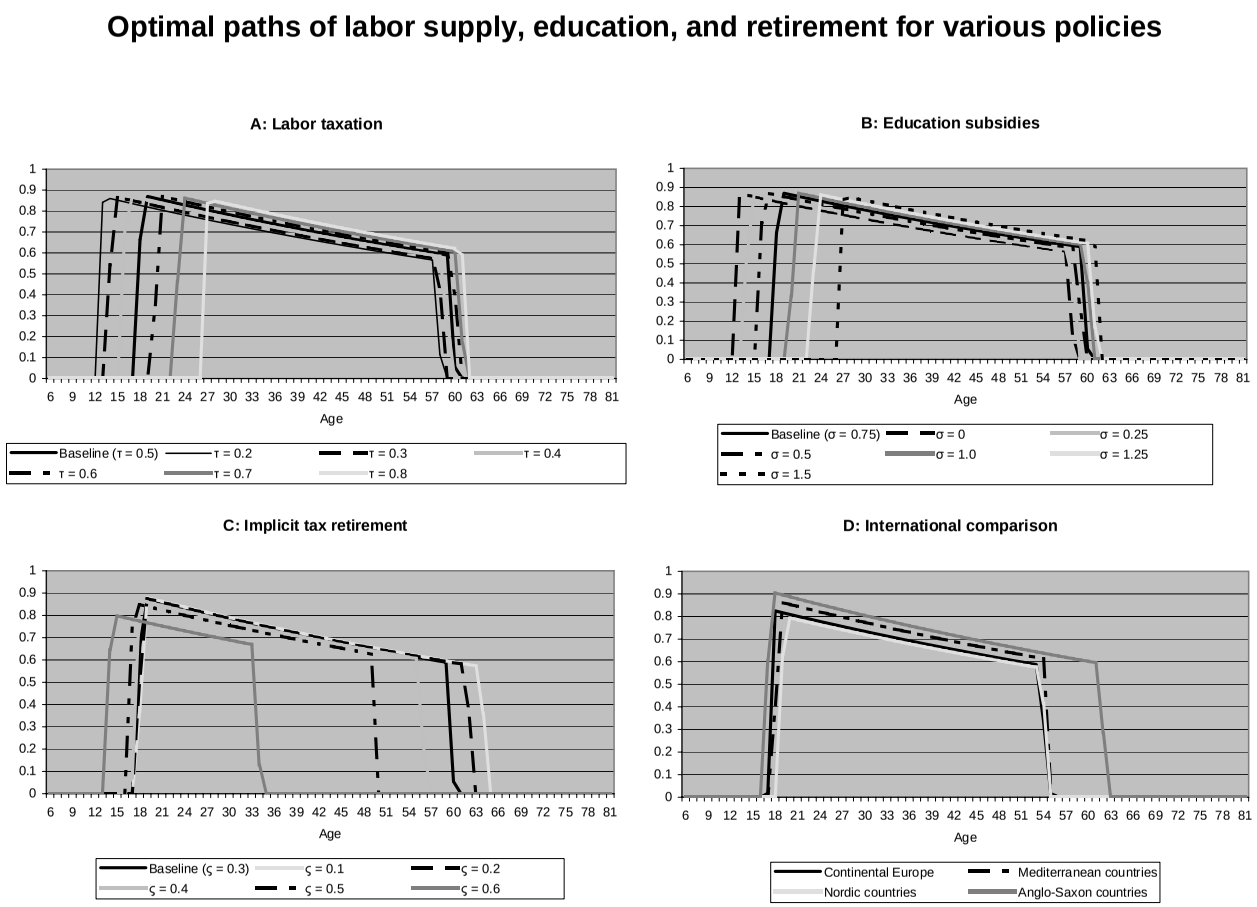
Figure 23:



Rates of Return to Human Capital Investment Initially Setting Investment to be Equal Across all Ages

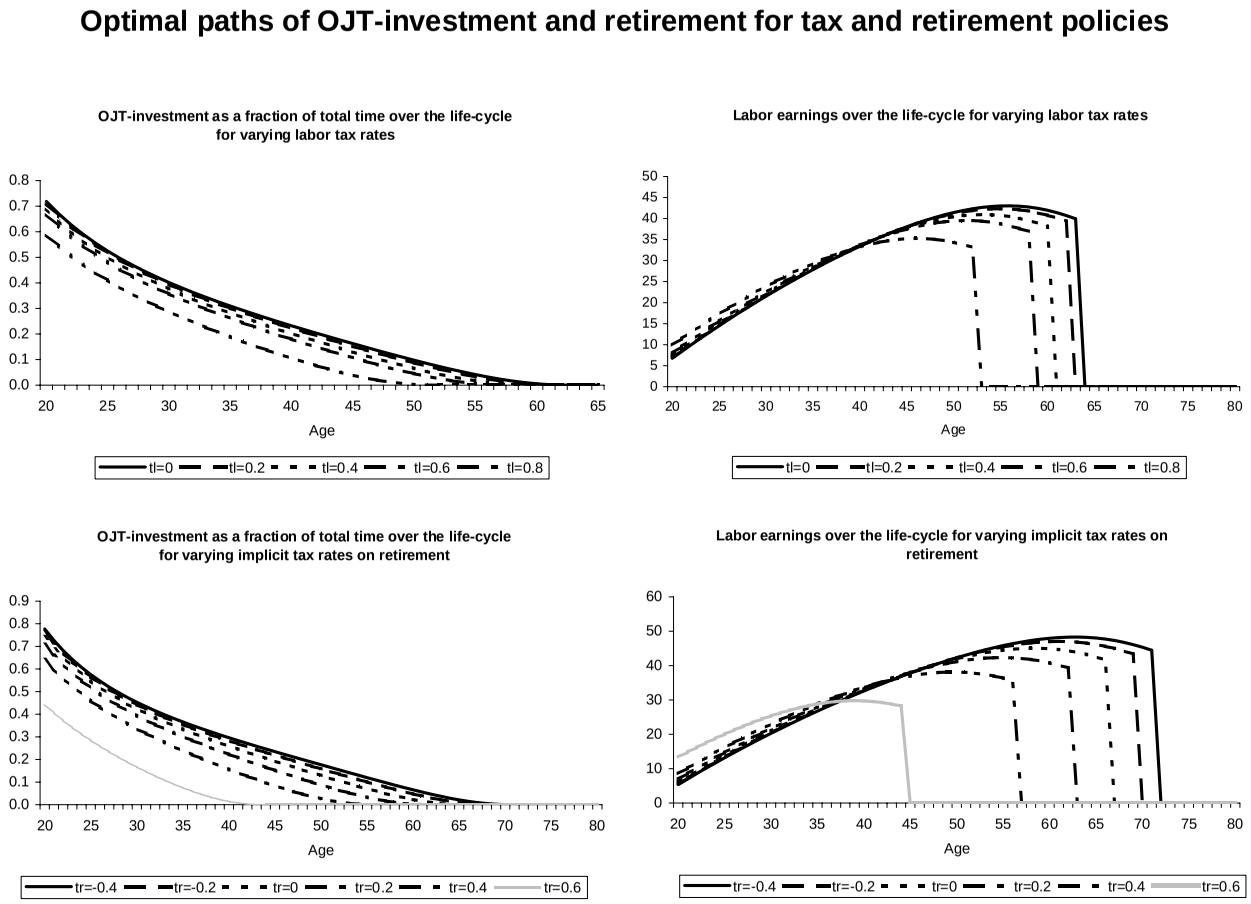
Source: Carneiro and Heckman (2003).

Figure 24: Optimal paths of labor supply, education, and retirement with exogenous OJT and varying policies



Baseline parameters: pure rate of time preference $\rho = 0.02$, real interest rate $r = 0.04$, intertemporal elasticity of substitution in consumption $\theta = 2$, intertemporal elasticity of labor supply $\varepsilon = 0.5$, human capital production function: $W(S) \equiv AS^{\alpha}$, $\alpha = 0.55$, $A > 0$, uncompensated elasticity labor supply 0.2, uncompensated elasticity retirement 0.2, direct costs of education $P = 10$, time horizon $T = 75$ years. Baseline policy: tax rate labor $\tau_L = 0.5$, tax rate savings $\tau_A = 0$, subsidy on education $s = 0.75$, and retirement wedge $\varrho = 0.3$. See Jacobs (2009a) for more details.

Figure 25: Optimal paths of OJT-investment, earnings, and retirement for varying policies



Baseline parameters: pure rate of time preference $\rho = 0.02$, real interest rate $r = 0.04$, intertemporal elasticity of substitution $\theta = 1.25$, uncompensated elasticity retirement $= 0.2$, Cobb-Douglas production function for OJT: $F(I_t, H_t) \equiv (I_t H_t)^{\alpha}$, $\alpha = 0.6$, time horizon $T = 60$ years. Baseline policy: tax rate labor $\tau_L = 0.5$, tax rate savings $\tau_A = 0$, and retirement wedge $\varrho = 0.3$. See Jacobs (2009b) for more details.