Human Capital, Retirement and Saving

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Abstract

Traditionally, human capital investment, retirement decisions and saving choices have been studied in isolation from each other. This chapter derives a comprehensive framework to simultaneously analyse human capital investment, retirement decisions, and (pension) savings choices. Knowledge of life-cycle interactions between human capital, retirement and savings is important in understanding individual behaviour and in making solid policy recommendations. In the future, research efforts should be focused on i) understanding the impacts of non-competitive labour markets on human capital investments, ii) measuring non-observable investment in human capital using structural econometrics, iii) using quasi-experiments and micro-panel data to estimate the impact of institutions and to discriminate between competing theories of earnings determination.

1 Introduction

Understanding the life-cycle interactions between investments in human capital, retirement choices and pension savings is highly policy-relevant. Most Western governments will be confronted with the consequences of demographic ageing in the upcoming decennia. Tax bases will shrink, due to the retirement of older generations of workers. Outlays on state pensions and healthcare will rise substantially. Pension systems with strong intergenerational risk sharing face difficulties as well, since it will become more difficult and costly to smooth pension risks over different generations by means of contribution adjustments. At the same time, individuals do not invest in skills, because they expect to retire early. And, individuals retire early because they have not invested in skills. As a result, many European countries are confronted with a vicious circle of low investments in on-the-job training of older workers and strong incentives to retire early.

Given these developments, policymakers are considering a range of policies to increase investment in skills, promote later retirement and pension savings. For example, all European countries have subscribed to the Lisbon agenda. One of its main targets is that the EU average level of participation in life-long learning should be at least 12.5% of

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the adult working-age population (25-64 age group) by 2010. Most countries have started to implement 'life-long learning' policies to promote investments in on-the-job training (OJT), so as to raise labour productivity and to improve the employability of especially older workers. In addition, governments aim to promote labour-market participation of older workers and to improve their employability so as to broaden tax and premium bases. In particular, (early) retirement schemes and labour markets are reformed in order to stimulate later retirement. Until recently, implicit taxes on continued work have often been so high that individuals were 'thieves of their own wallet' if they did not retire early. Furthermore, many governments stimulate private pension saving, for example, through tax-favoured saving schemes, so as to reduce the dependency of pensioners on state pensions and collective occupational pension schemes.

Unfortunately, too little is known about life-cycle interactions between learning, retirement and saving, both theoretically and empirically. Generally, training, (pension) saving and wage determination are separately analysed, and no generally accepted theories are available to address these issues simultaneously. The consequence is that human capital policies are considered in isolation from retirement and pension policies. This chapter closely follows the theoretical structure of Jacobs (2009a) and Heckman and Jacobs (2010) to provide an analysis of the interactions between human capital investments in OJT, retirement choices and pension saving. In particular, retirement and pension saving affect the incentives to invest in human capital over the life cycle. By extending the time horizon over which investments in skills materialise, a higher retirement age promotes investments in OJT. Later retirement and OJT investment are therefore complementary. Generous support for early retirement therefore indirectly discourages investment in OJT. Individuals also make a life-cycle portfolio choice by investing in both financial and human capital. Stimulating retirement savings implies that savings in human form are discouraged. The intuition is that the opportunity return at which future labour earnings are discounted increases. Equivalently, arbitrage between financial and human investments ensures that both assets must earn equal returns. Hence, human capital and financial capital are substitutes over the life cycle. Simulations of various tax and retirement policies illustrate the importance of life-cycle interactions between human capital, retirement and pension saving.

Labour-market institutions and welfare-state arrangements appear to be crucial to understand economic incentives for OJT investments. Labour-market institutions—such as employment protection, wage setting of unions, efficiency wages, deferred payment schemes and minimum wages—could rotate the wage profile over the life cycle and may result in wage compression. This may be the consequence of various welfare-state arrangements that affect wage setting such as benefits for sickness, disability and unemployment as well as pensions and early retirement schemes. In addition, the value of outside options for workers typically increases as they become older. Both wage compression and rotation of wage profiles can harm the incentives to invest in skills. In particular, by reducing the wage differences between skilled- and unskilled workers, the incentives to become skilled diminish. Further, by rotating the wage profile over the life cycle, younger workers will invest too much, and older workers too little, in human capital.

The main message of this chapter is that any policy reform should take into account the dynamic interactions of OJT investment, retirement and pension saving. The

following policy-relevant implications appear from the analysis:

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

After having elaborated on the theoretical structure from which these arguments are derived, the chapter will discuss in more detail i) its underlying assumptions, ii) its empirical content, and iii) various competing theories. This exercise will reveal a number of important gaps in our knowledge. Attention will be paid to the assumptions regarding the functioning of labour and financial markets. Labour-market distortions due to, for example, unions or minimum wages, are expected to affect the incentives for OJT training. Similarly, borrowing constraints or non-insurable risks affect the incentives to invest in human capital.

The chapter will elaborate on various theoretical, empirical and methodological issues when bringing the theory to the data and will demonstrate that the empirical evidence is very much in line with the theoretical framework. However, certain important data limitations prevent us from directly proving empirically that the standard, neoclassical human capital model causally explains life-cycle earnings. The most pressing problem is that investments in OJT are hard to measure by the analyst, and that most proxies used in empirical analyses have substantial shortcomings. Other, competing theories of life-cycle earnings determination and investments in human capital could explain salient features of the data as well. The chapter will therefore discuss theories of specific investments in human capital (Becker, 1964), and general training in distorted labour markets (Acemoglu and Pischke, 1998, 1999), incentive theories and deferred payment schemes (Lazear, 1976, 1979, 1981), and learning-by-doing theories (Killingsworth, 1982; Heckman et al., 2002). The argument will be made that theories of specific investments and training in non-competitive labour markets have some empirical implications that are counter-factual. Moreover, learning-by-doing and on-the-job training models are hard to distinguish from each other once general equilibrium feedbacks have been taken into account. Theories on deferred payments are not concerned with human capital investments, but do probably explain part of the patterns in earnings over the life cycle.

The chapter contends that the remaining gaps in knowledge are large. In order to close the gaps, future research should be directed towards using structural models that aim to identify non-observable human capital investments by imposing theoretical structure on the data. However, identification of these non-observables is as good as the theoretical structure used. Hence, better theories are needed to understand investments in human capital as well as retirement and pension choices over the life cycle. In particular, development of models with labour-market distortions appears to be key in understanding life-cycle choices in European-style labour markets. As regards the data, micro-panel data are needed to properly estimate life-cycle models. Little can probably be learned from cross-country panel studies, since the time-series variation is often too limited, and identification of effects on the cross-sectional dimension of the data is often rather problematic, from an econometric point of view. Researchers from multiple

subdisciplines should join forces to make scientific progress. In particular, structural micro-econometricians and micro-, macro-, and labour theorists should cooperate.

2 A stylised theory of training, retirement and saving

Jacobs (2009a) develops a standard life-cycle model with a representative household to analyse training, retirement and saving decisions. His analysis closely follows Heckman and Jacobs (2010) and Jacobs (2009b) by adding an endogenous retirement decision to the otherwise standard Ben-Porath (1967) model of OJT investments (see also Heckman, 1976; and Weiss, 1986). This is the canonical model to analyse OJT. Although savings are made to ensure consumption smoothing over the life cycle, most savings will be made for the retirement period, in which individuals have no labour earnings. The individual starts his or her life without financial assets and can borrow and lend on a perfect capital market. There is no endogenous (initial) education choice, and there are no labour-supply decisions on the intensive margin (that is, hours of work). The model is deterministic and there is no risk in earnings, longevity, and so forth. A partial equilibrium set-up is chosen in which the paths of the rental rates for human capital and the interest rate are exogenously given.[2] Labour markets are perfectly competitive and frictionless. Upon entering the labour market, the individual may devote some time to training on-the-job in order to augment his or her stock of human capital, which raises his or her future earnings potential. The individual optimally chooses i) consumption at each moment of the life cycle, ii) human capital investment at each moment while active in the labour market, and iii) the date of retirement so as to maximise lifetime utility.

The saving decision is governed by the standard Euler-equation for 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 saving with respect to net after-tax returns. A larger tax on saving reduces the slope of the consumption profile if the substitution effect in saving dominates the income effect (the empirically relevant case).

Optimal retirement choices ensure that 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 costs are the net forgone labour earnings in the last year on the labour market. The retirement choice is distorted not only by the implicit tax on retirement, but also by the explicit labour tax levied on all labour earnings. This direct tax is often overlooked in retirement studies. Due to wealth effects, richer individuals retire earlier. In addition, a larger tax on (pension) saving gives stronger incentives to retire later. Intuitively, as individuals accumulate fewer assets, a higher tax on (pension) savings provokes a wealth effect, which delays retirement. The individual has stronger incentives to retire later if he or she has acquired more human capital on-the-job, since this raises forgone labour earnings while being retired. Thus, better-skilled workers retire later, when the income effect of higher skills is outweighed by the substitution effects of

[2] This would be the case in small, open economies with perfect capital mobility and perfect substitution between labour types in labour demand.

higher skills. Similarly, if individuals do not train, and end their career with low levels of human capital, the incentive to retire will be stronger, since the opportunity costs of doing so diminish.

Investment in on-the-job training is such that the marginal costs of an hour devoted to OJT human capital investment (that is, net forgone labour earnings) should be equal to the discounted value of the marginal benefits in terms of higher future wages. Investment in OJT increases if the individual has a higher level of initial education before entering the labour market. Intuitively, initial education raises the productivity of OJT investments, since initial education and OJT are complementary. Investment in human capital falls continuously over time, until it becomes zero at the date of retirement. The reason is that the time horizon over which the returns to the investments can be reaped diminishes, as individuals grow older. At the date of retirement, investments have no remaining value, since the returns on OJT are zero if individuals do not work anymore. The net return on the investment in human capital (that is, after depreciation) must be equal to the net return on financial saving. The labour tax does not affect the net return to human capital, since all opportunity costs and benefits from investments in human capital receive a completely symmetric tax treatment (Heckman, 1976). A higher tax on financial saving makes human capital investment more attractive by lowering the effective rate at which future wage increases are discounted, and by delaying retirement.

Jacobs (2009a) simulated the model for a reasonable set of parameters. Extensive details on the simulations and sensitivity analyses can be found there. All simulations below use the same benchmark values of the parameters. In particular, individuals start working at age 20 and die at age 80. The pure rate of time preference is assumed to be 2.5 per cent, and the real interest rate equals 5 per cent. The elasticity of the human capital production function is 0.6 (see Trostel, 1993). The depreciation rate of human capital is two per cent.[3] The uncompensated elasticity of labour-force participation of older workers with respect to the implicit tax on retirement (thus, including wealth- and income effects) takes a value of 0.2.[4] The tax rate on labour income amounts to 50 per cent.[5] The tax rate on interest income is set at 30 per cent, and the implicit tax on retirement is 30 per cent. [6] The model parameters are calibrated such that the individual retires at age 60, he or she invests 71% of his or her time endowment at the start of the career in human capital, and the individual's gross labour earnings per year are 30.6 (thousand euro), on average, during working life.

The baseline time paths of consumption ($C(t)$), the value of total investment in human capital ($WI(t)H(t)$), total labour earnings ($W(1 - I(t))H(t)$), and total human capital ($WH(t)$) are plotted in Figure 1, where human capital at date t is denoted by $H(t)$, investment in human capital (as a fraction of total time) is denoted by $I(t)$, and the

[3] Depreciation of human capital appears to be modest, since most earnings profiles do not tend to level off much at the end of the life cycle (Heckman et al., 1998).

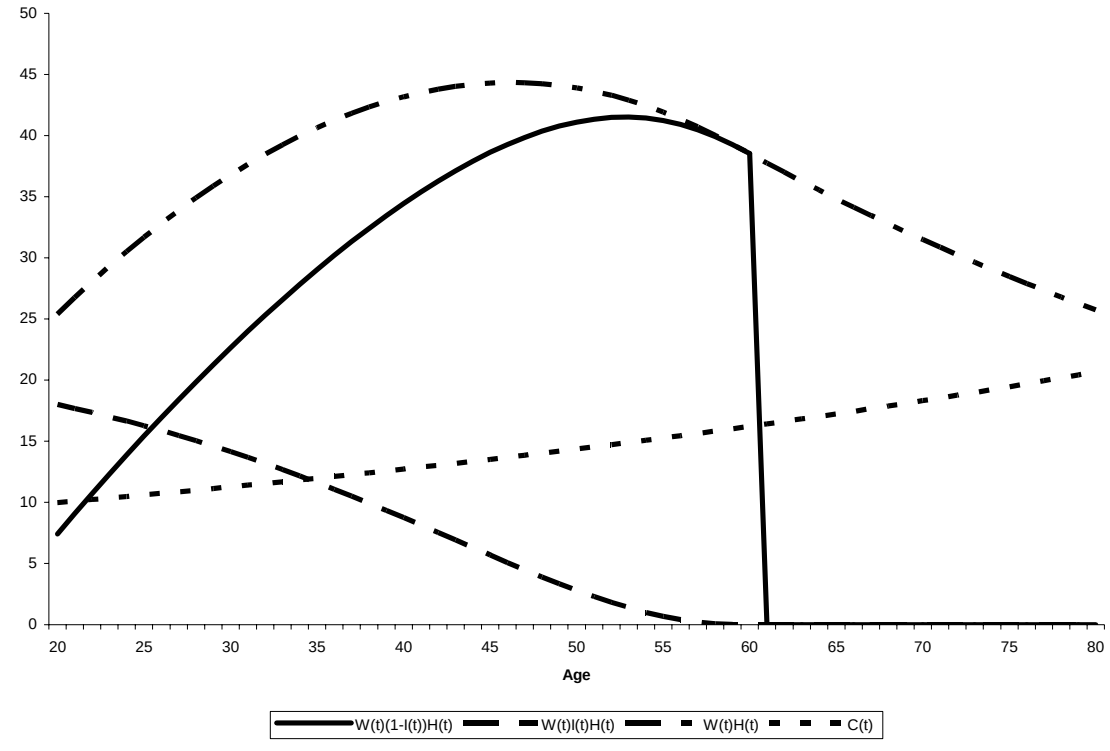
[4] The estimates in Gruber and Wise (1999, 2002), OECD (2004) and Duval (2004) imply that the uncompensated elasticity of labour-force participation of older workers with respect to the implicit tax on retirement (thus, including wealth- and income effects) is approximately one-third.

[5] Total marginal tax wedges on labour income (including employer contributions and local taxes) are on average 51% for 16 advanced OECD countries (Jacobs, 2009b).

[6] Gruber and Wise (1999), OECD (2004) and Duval (2004) show that the implicit tax on retirement amounts to around 30% for an older worker aged 55–65 years, although there are substantial cross-country differences.

constant rental rate per efficiency unit of human capital is given by *W*. Investment in human capital is high at the beginning of the working career, and declines monotonically until the retirement age is reached. The reason is that the payback time of these investments continuously decreases. Hence, returns on investments fall over time. Indeed, labour earnings drop to zero at the retirement age of 60. The life-cycle profile of labour earnings steadily increases until it peaks at age 53, and then decreases slightly afterwards. This reflects both the investment in OJT before the peak and the depreciation of human capital after the peak. There would be no decline in labour earnings at the end of the life cycle in the absence of depreciation of human capital. Also, the total value of the time endowment is plotted ($WH(t)$). This is a measure for total labour productivity, since rental rates are constant over time. It peaks at age 46, before the peak in earnings (Ben-Porath, 1967; Heckman, 1976). The intuition is that at age 46, individuals are still investing about 10% of their time endowment in OJT. Consequently, total labour productivity peaks earlier in the life cycle than total earnings do. The individual also has a valuable time endowment after retirement, although it is steadily depreciating. Investment in human capital drops to zero at retirement, since the marginal value of investment in human capital has become zero at that date. Finally, the life-cycle path of consumption is increasing. The reason is that the net interest rate is larger than the pure rate of time preference. Note that the consumption path is substantially lower than the earnings path, since the latter are denoted in gross terms (that is, before 50% income taxes).

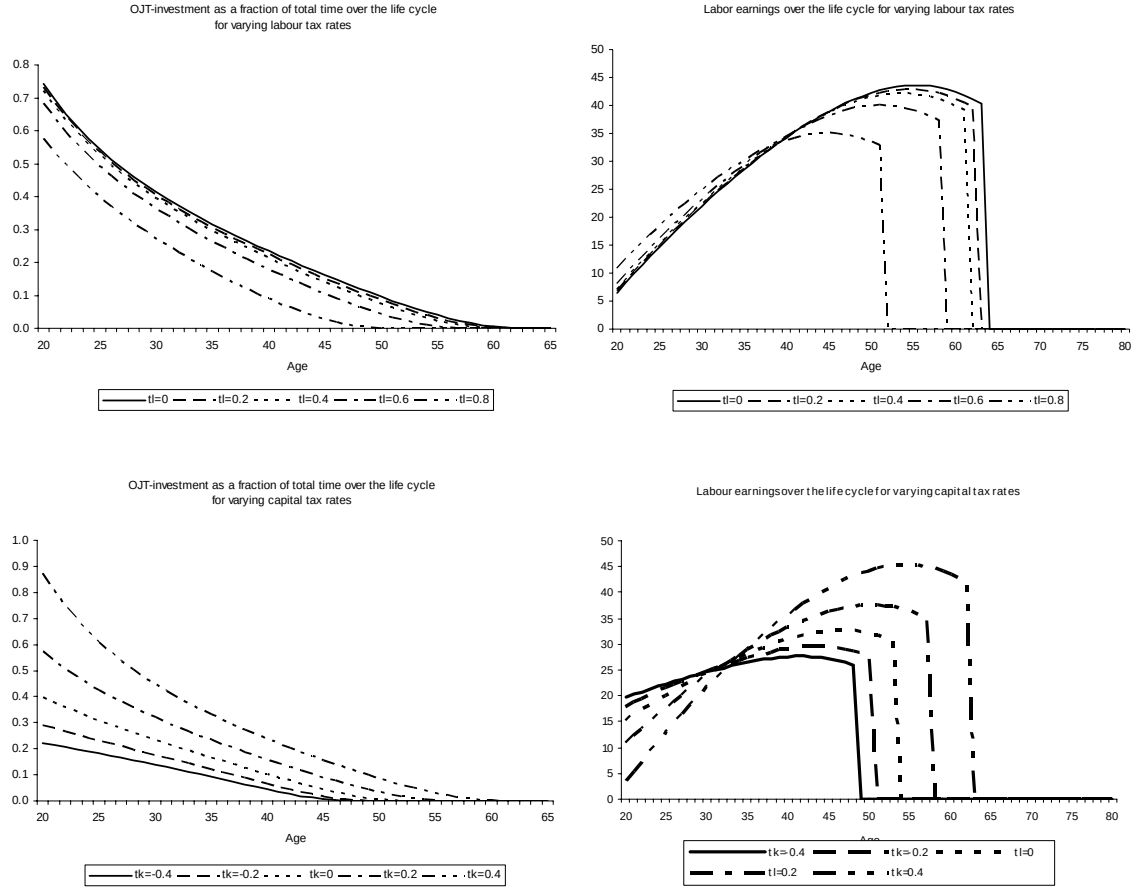
Figure 1 – Labour earnings, consumption, OJT investment and human capital over the life cycle



Source: Jacobs (2009a)

Figure 2 plots the simulated patterns of OJT investment and life-cycle earnings for different values of the labour tax rate and the capital tax rate. Life-cycle investments in OJT are affected by the labour tax rate through its impact on retirement only (recall that all OJT costs are deductible). Since retirement is distorted by the presence of the implicit tax, a higher explicit tax on retirement reduces OJT investments to a considerable extent, since the payback period of investment in human capital falls substantially. As a result, life-cycle earnings profiles shift towards the origin. As OJT investments fall, the peak of earnings will be earlier. Moreover, since less time will be invested in OJT, earnings when young increase slightly. However, at later ages this is more than offset by lower stocks of human capital, so that earnings decline. This, in turn, makes earlier retirement more attractive, as the opportunity costs of retirement are lower when wages in the final year of work are lower. This graph indirectly shows that policies stimulating earlier retirement can have important consequences for OJT investments (more on this below).

Figure 2 – Labour earnings and OJT investment over the life cycle for varying labour- and capital income taxes

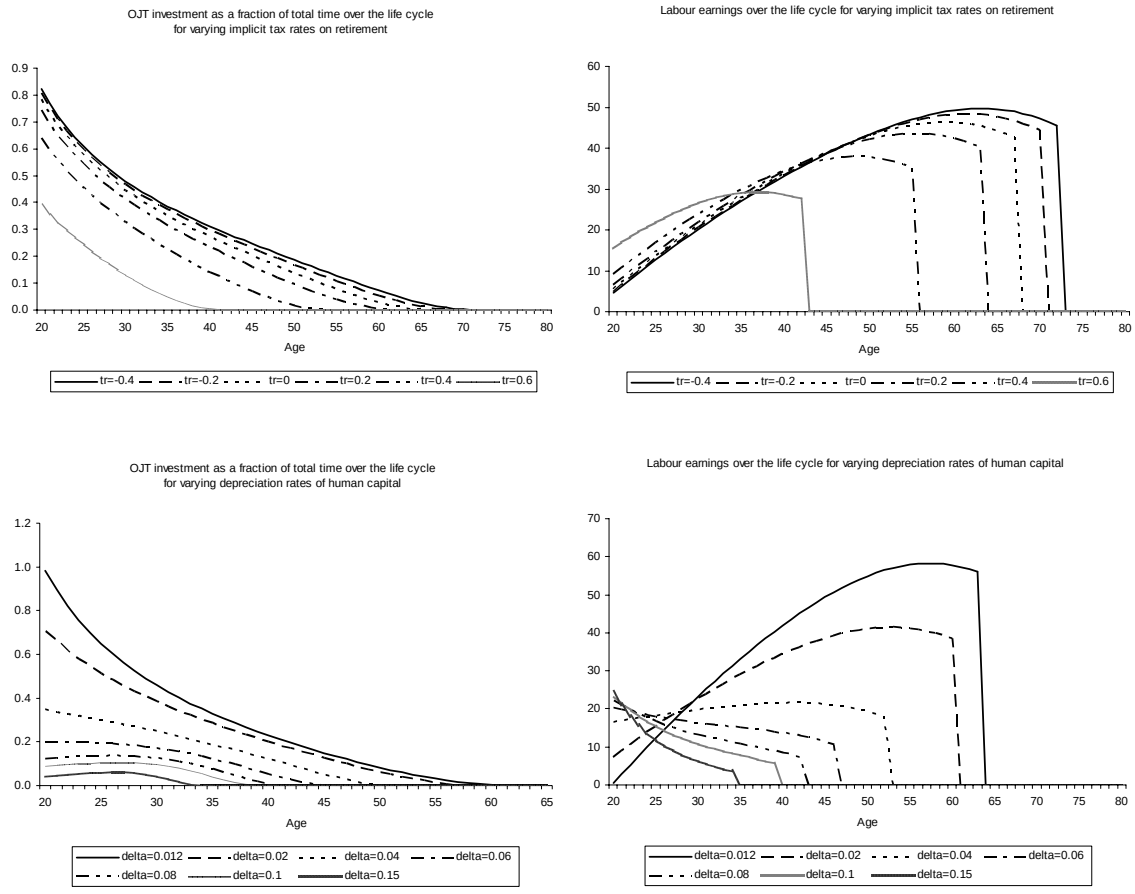


Source: Jacobs (2009a)

A higher capital tax boosts investments in human capital, since saving becomes less attractive compared to investment in OJT. Again, as was seen under the labour tax, earnings profiles rotate, but now in the reverse direction. Especially at the beginning of

working careers, OJT investment increases; hence, total gross labour earnings fall. Over time, however, this fall in earnings will be compensated by rising levels of human capital, which result in increasing labour earnings at later ages. The peak in the earnings profile shifts to later ages, and individuals end their working careers with substantially higher earnings. This graph demonstrates the fundamental interactions between saving policies and OJT investments. Indeed, human capital investments can be seriously affected if governments want to boost saving by lowering the capital tax (or even offering tax incentives for saving). Consequently, OJT policies cannot be seen in isolation from pension- and saving policies.

Figure 3 – Labour earnings and OJT investment over the life cycle for varying implicit retirement taxes and depreciation rates of human capital



Source: Jacobs (2009a)

Figure 3 plots the investment and earnings profiles for various implicit tax rates on retirement and depreciation rates of human capital. A higher implicit tax on retirement—much like the labour tax—provides stronger incentives to retire early from the labour market. Indeed, investment in human capital falls during all ages. Although this increases earnings temporarily (as workers have higher labour earnings at the beginning of the life cycle), their wage growth over the life cycle will be substantially lower. Since less human capital will be accumulated, workers end up with lower wages at the end of their careers.

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

A larger rate of depreciation of human capital has similar effects as a higher implicit tax on retirement, except that the consequences of higher depreciation rates are more severe. Indeed, the higher depreciation rate makes saving in financial capital relatively more attractive at all times; hence, investments in human capital decrease throughout the life cycle. Indeed, at relatively modest depreciation rates (5% and higher), earnings profiles even become downward sloping over the life cycle. The reason is that the depreciation rate has become larger than the real interest rate, so that human capital decumulation has become optimal.

The messages from the retirement-augmented Ben-Porath model are clear and simple. Investment in OJT shifts the wage profiles upwards, which implies that there are positive returns to OJT investments. Investment in OJT increases if the retirement date increases (lower explicit and implicit taxes on retirement), if the opportunity return on saving decreases (higher capital taxes), and if the depreciation rate is lower. The life-cycle earnings profile is typically 'hump-shaped'. Moreover, policies that boost investment in human capital depress earnings at the beginning of the life cycle and boost earnings at later ages. This is because the cost of investment is forgone working time. Finally, the policy environment is critical to understand life-cycle patterns in OJT investment, labour earnings, retirement ages and savings behaviour. Indeed, financial saving and human capital investments are substitutes, whereas retirement and human capital investments are complements. However, caution should be exercised in drawing strong quantitative conclusions. All simulations are driven by the particular assumptions on the parameters of the model. Jacobs (2009a) provides extensive sensitivity analyses for widely differing parameters.

Jacobs (2009a) thus provides a parsimonious theory of investment in human capital, saving and retirement that contains a number of empirically testable implications:

- Earnings tend to be 'humped-shaped', and labour productivity peaks before earnings;
- Investment in human capital decreases with age;
- Investment in training increases if productivity of training is larger (due, for instance, to larger investment in initial education;
- Retirement ages decrease with the implicit or explicit tax rate on continued work, which in turn reduces OJT;
- (Retirement) savings decrease with a larger tax on savings, which in turn boosts OJT.

3 Empirical content

This section argues that the empirical evidence is in line with the stylised features of the theory described above.

3.1 Earnings profiles and OJT

Age-earnings profiles are indeed hump-shaped, which follows from the commonly

estimated Mincer wage equation, with experience (age) and experience squared (age squared) (see Card, 1999).

Direct measurements of productivity over the life cycle are indeed quite suggestive of a hump-shaped pattern of productivity of the life cycle as well. Note, again, that productivity does not equal labour earnings, because of investments in training. Skirbekk (2005) surveys the literature and finds the following stylised facts. Cognitive abilities decline after some stage in adulthood. Older workers compensate withering cognitive skills with sufficient working experience (for example, by OJT or learning-by-doing). Based on subjective evaluations of managers, age-productivity profiles do not seem to display systematic patterns. Evaluations by workers suggest that worker productivity indeed falls at older ages. Objective evaluations (based on measured outputs) suggest that quantity and quality of output show a hump-shaped pattern with age. Importantly, Skirbekk also presents empirical evidence that labour productivity measures peak before labour earnings, which is also theoretically predicted by Jacobs (2009a).

However, from the hump-shaped pattern of earnings one cannot conclude that they are *caused* by investments in OJT. Indeed, other theories of wage determination over the life cycle could also be relevant (deferred payments, learning-by-doing, wage-setting institutions, and so forth). Skirbekk resorts to Lazear's (1976) theory of deferred payments to explain the earnings profiles. This theory will be discussed later in more detail as well.

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

3.2 Time horizon and complementarity with initial education and OJT

Given a finite horizon, younger workers are expected to participate more in training, since the payback period of their investments is larger. Furthermore, better-educated workers are also expected to invest more in training, since training increases with the productivity of training activities. Both are indeed found to be stylised facts in the data (Leuven, 2005; Bassanini et al., 2006).

3.3 Participation and OJT

Another stylised fact is that male workers have higher participation rates in training than female workers do. One obvious explanation is that men work more hours and have higher labour participation. Consequently, their 'utilisation rates' of OJT human capital are higher. Jacobs (2009a) does not allow for an endogenous work/participation decision (hence, this feature has been missing thus far in the discussion). However, Heckman and Jacobs (2010) extend a similar model with endogenous labour supply and find that workers with less labour supply utilise their human capital less and therefore invest less in OJT. Women could be outside the labour market because they invest more in the human capital of children, which is something that we abstracted from.

3.4 Retirement and OJT

Gruber and Wise (1999) show that the labour-force attachment of the average worker is rapidly declining with age. Many workers retire long before statutory retirement ages via all kinds of early-retirement schemes. Pension benefits can be generous as well. Pension-replacement incomes in Continental European are quite high, and about 60-80% of pre-retirement earnings for an average worker (OECD, 2005). In most countries, pensioners receive the main part of their pension incomes from PAYG schemes. Exceptions are the Anglo-Saxon countries, the Netherlands, Sweden and Denmark, which also heavily rely on substantial private funding—either through DB/DC occupational pensions or individual saving schemes (OECD, 2005). It is not easy to make international comparisons because the institutional details vary from country to country. Gruber and Wise (1999) summarise the impact of early retirement schemes on the labour market by the implicit marginal tax rates imposed on an additional year of work. Duval (2004) and OECD (2004) demonstrate that early retirement schemes do indeed cause very high marginal tax rates on pre-retirement incomes. Moreover, retirement ages and benefit generosity are very negatively related. Gruber and Wise (1999, 2002) present strong evidence that this is a causal relation. In recent years, some countries have attempted to reform their pension schemes. The Netherlands, Germany, France and Italy are examples.

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

3.5 Pensions

Little is known about the impact of saving or pension policies on the incentives for OJT investments. There doesn't seem to be any empirical evidence that directly estimates the impact of saving and pension policies on OJT investment. At least theoretically, saving and investing in human capital are substitutes for a given level of overall (that is, human and financial) saving. Hence, a higher tax rate on financial saving tends to boost human capital investments. However, also the level of saving can be affected by taxes on savings, depending on offsetting income and substitution effects. Clearly, tax incentives are important for financial saving decisions (see Bernheim, 2002). The earlier empirical literature found only small effects of tax incentives on saving. On balance, however, most of the recent empirical evidence clearly points to a dominant substitution effect in saving (Bernheim, 2002).

4 Theoretical, empirical and methodological issues

Does Jacobs (2009a) provide the correct framework to analyse the interactions between human capital, retirement and pensions? This cannot be answered, for various reasons. First of all, his model made a number of important assumptions, which may not be warranted, from an empirical point of view. Second, the standard human capital model may not be the right model to capture life-cycle earnings. Various competing theories are

available. Third, both measurement and methodological problems prevent the direct testing of the model. These issues will now be discussed in more detail.

4.1 Modelling assumptions

The most important modelling assumptions include the following:

- Perfectly competitive labour markets: the wage rate per unit of skill is constant and equal to productivity per unit of skill;
- Life-cycle earnings profiles are driven by investments in human capital;
- Perfect capital markets: all assets are liquid, borrowing and lending at common risk-free rate is possible;
- Perfect insurance markets: there is no risk/uncertainty, and life expectancy is certain;
- No heterogeneity: there are no differences in abilities and life spans;
- Rational expectations, individuals are blessed with perfect foresight: there is no myopia, no hyperbolic discounting, and so forth.

Subsection 4.2 is entirely devoted to a discussion of the assumption of perfectly clearing labour markets. This seems to be the most important assumption made so far, and will be discussed extensively below. In addition, subsection 4.2 discusses various competing theories that could also explain observed patterns in the data. The remainder of this subsection briefly discusses the other assumptions.

Capital-market failures

Naturally, capital markets can fail, and not all assets are perfectly liquid. Illiquid housing wealth, for example, represents a large fraction of total financial wealth in household portfolios in most Western countries. Moreover, individuals can be borrowing-constrained. In some countries, such as the Netherlands, individuals are obliged to save for retirement in collective labour agreements. This also generates borrowing constraints if individuals cannot collateralise their pension wealth. Both liquidity and borrowing constraints can, in theory, impede socially desirable investments in human capital.

The micro-econometric literature contains ample empirical evidence that borrowing constraints could be important for consumption choices (see Hall and Mishkin, 1982; Hayashi, 1985; Mariger, 1987; Zeldes, 1989; Attanasio, 1995; Browning and Lusardi, 1996; Blundell, 1988). Empirically, direct evidence is missing of borrowing constraints on investments in on-the-job training (see Bassanini et al., 2006). The prime reason is that both costs and returns are hard to verify for the analyst—an important issue that will receive attention below. A large literature identifying the role of liquidity and borrowing constraints for initial education only finds small effects for the lower end of the income distribution (see Carneiro and Heckman, 2003; Cunha et al., 2006, and the studies they cite). There is thus some temptation to conclude that borrowing constraints should probably not be the primary focus of future research. Indeed, in the simulations, savings are made mainly for the purpose of saving for retirement (Jacobs, 2009a). Hence, if this theory is only roughly plausible, then binding borrowing constraints are expected to affect the results for training, although probably not to a very large quantitative extent.

Risk and uncertainty

We also abstracted from non-insurable risk and uncertainty, thereby ruling out any precautionary savings or any effects of risk on human capital investments. Browning and Lusardi (1996) argue that precautionary saving, in particular, is an empirically important component of the financial savings of households.

How risk affects human capital investment is critically determined by the ways in which human capital affects the risk to which individuals are exposed (Jacobs et al., 2008). If human capital investment increases risk in labour earnings, then risk-averse individuals will underinvest so as to reduce their exposure to risk. However, if human capital investment reduces the exposure to risk, the opposite holds true: that is, risk-averse individuals will overinvest (see also Levhari and Weiss, 1974). Empirically, little is known about the risk properties of human capital (see Jacobs, 2007; and Jacobs et al., 2008, and the references cited there). Indeed, better-skilled individuals seem to have both a larger variance in earnings and a lower incidence of unemployment, sickness and disability. Moreover, better-skilled individuals participate more and retire much later. Consequently, investment in human capital can both increase and decrease earnings risk. The impact of longevity risk on human capital investment is shown to be ambiguous in theory, as Sheshinksi (2009) recently showed.

Neither theory nor empirical research seems to be available that simultaneously addresses uncertainty in human capital returns and risky returns on savings. Note that labour earnings do not directly measure the marginal return to investing one unit of resources in human capital. Therefore, it is not clear how returns to human capital co-vary with the returns on risky assets, and how the covariance structure changes over the life cycle. Allowing for uncertainty seems to be a potentially important avenue for future research—especially when it comes to understanding financial planning, skill maintenance, and retirement and pension choices. However, a thorough analysis of risk in life-cycle settings with endogenous human capital formation requires much more advanced theory and empirical research.

Heterogeneity and distributional issues

Thus far, the model has completely abstracted from distributional issues. Instead, the focus has been on a positive analysis of understanding the behavioural interactions between OJT, pension saving, and retirement. It has been argued that promoting pension saving or introducing early retirement schemes may have (unintended) adverse consequences for investments in human capital. However, this does not imply that these policies are socially undesirable. Naturally, many public policies could be justified by distributional concerns. For example, it may well be worthwhile to introduce distortions in retirement choices if this helps to redistribute resources to the lifetime poor—those who have been born with low ability or have been hit by adverse skill shocks during the life cycle (Bovenberg and Jacobs, 2009). This could be applied more generally. Heterogeneity and finite lives render the taxation of labour income optimal (Mirrlees, 1971) and could also make taxation of capital income optimal (Jacobs and Bovenberg, 2008). However, the implications of life-cycle considerations for the optimal setting of tax rates on labour or capital income over the life cycle are not yet fully crystallised (Diamond and Banks, 2009).

Two other potentially important sources of heterogeneity could originate from differences in depreciation rates for human capital or differences in life expectancy. Typically, less-skilled individuals seem to have higher depreciation rates of human capital (due to physically more-demanding jobs) and have a lower life expectancy (due to more unhealthy lifestyles). A higher life expectancy could also be viewed as the result of investment in human capital (that is, investment in health). Future research should dwell upon these issues in more detail.

Rational and forward-looking behaviour

Like any life-cycle model, also Jacobs (2009a) relies heavily on the forward-looking- and rational behaviour of households. Recent developments in behavioural economics have pointed to the weaknesses of this traditional framework for analysing saving- and investment decisions over long time horizons—especially when it comes to retirement and pension decisions. Many of the arguments raised in the behavioural economics literature could also be applied to investment in human capital over the life cycle. Certainly, concepts from behavioural economics could be fruitfully applied in this area.

Health, fertility and bequests

The theory presented above also abstracted from various important aspects such as health, fertility and bequests. This is not to say that these issues are not important—on the contrary. However, one must start somewhere in considering life-cycle interactions between human capital, retirement and pensions. Naturally, health conditions are an important ingredient of both labour-market outcomes and retirement choices. Again, we expect that interactions between human capital investments and health are important. Health could even be seen as a specific form of human capital. Also, longevity risk can be endogenous and (partly) determined by human capital investments. Similarly, the model paid no attention to fertility choices—and it is well known that these are importantly associated with skill levels of individuals. How fertility choices, human capital investments and pension policies interact is less well known, however—let alone, what optimal policies should look like. The model, moreover, abstracted from bequests and issues on intergenerational redistribution (see also Cremer and Pestieau, 2006). In real life, these are importantly intertwined with the design of pension and retirement policies. Moreover, financial bequests could be substitutes for bequests in the form of investment in human capital (Grossman and Poutvaara, 2009).

4.2 Imperfectly competitive labour markets and alternative theories for life-cycle earnings

The most important assumption in the theory outlined above is that the labour market is perfectly competitive and frictionless. The rental rate of human capital equals the productivity per efficiency unit of human capital.[7] However, a perfectly competitive

[7] In addition, workers with different vintages of OJT human capital are perfect substitutes in production, so that rental rates per unit of human capital are equalised across all individuals with different levels of OJT human capital. At first sight, it would seem implausible that this would indeed be the case. Empirical

labour market is unlikely to serve as a valid approximation for many European labour markets, which are characterised by all sorts of frictions, institutions and government interventions. In non-competitive labour markets, the theoretical connection between the productivity per efficiency unit of human capital and the price per efficiency unit of human capital is generally lost. Wages (or more precisely, rental prices per unit of human capital) then do not purely reflect productivity, but also market frictions. Moreover, the rental rates do not need to be constant over the life cycle.

In addition, our model had assumed that the Ben-Porath (1967) human capital model is the correct explanation for the life-cycle earnings patterns observed in the data. Nevertheless, other theories can also explain why earnings profiles are hump-shaped. Some of these alternative theories are directly tied to frictions in the labour market. These are discussed in this section as well. The main message of this section is that understanding the working of the labour market is key to understand the interactions between training, saving and retirement.

Minimum wages

A wage floor in an otherwise competitive labour market destroys employment for all workers that have labour productivity below the wage floor. This results in involuntary unemployment among these workers. Wage floors increase the wages of unskilled workers relative to skilled workers. Consequently, incentives to invest in OJT diminish. Minimum wages may also generate general equilibrium effects on the wage structure by changing relative supplies of workers (Teulings, 2003). In addition, the employment probabilities of low-skilled workers diminish, and incentives to become skilled improve. Hence, the effect of wage floors on skill formation is ambiguous. If the adverse employment effects on the low skilled generate sufficiently strong incentives to counter the decline in the skill premium, then investment in human capital might even increase (Gerritsen and Jacobs, 2010).

Unions, efficiency wages, frictions and insider-outsider problems

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

Labour-market frictions will not only have static effects, but also affect the wage structure over the life cycle. Employment protection legislation typically protects older

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evidence on these matters, however, is currently lacking.

workers better than it does younger workers. Labour turnover costs increase with workers' experience, due to higher firing costs, stricter employment protection legislation, seniority rules ('last in, first out'), and other terms of employment. Older workers may have more bargaining power than younger workers, which is relevant for labour markets with unions, search frictions, and insider-outsider problems. Typically, entitlements to social benefits increase with work experience and with income. Hence, outside options become more valuable as workers get older. All theories on non-competitive labour markets (unions, search frictions, efficiency wages, insiders-outsiders) then imply that wages are pushed more above market clearing levels as workers age. The actual design of labour-market policies, tax systems and social benefits is therefore critical in understanding how the outside options of workers are affected over the life cycle (see Bovenberg and Van der Ploeg, 1994). Most analyses in the training literature pay insufficient attention to the tax treatment of both earnings and outside options, the way in which entitlements to benefits are built up over time, whether benefits are related to final earnings, and so forth.

Worker incentives

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

Effect of non-competitive wage setting on OJT

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

If the wage profile indeed tilts in favour of older workers—due to labour-market frictions, institutions, or deferred payment schemes—then the incentives to invest in schooling and training can be considerably affected. Older workers face weaker incentives to maintain skills and will invest less in second careers because the opportunity costs of doing so increase. Younger workers, on the other hand, have

stronger incentives to invest in their careers early. However, if the tilting wage profile also affects unemployment rates, then older (younger) workers might get also stronger (weaker) incentives to invest in human capital so as to avoid unemployment. The tilting of the wage profile can promote steeper depreciation of human capital over the life cycle. Incentives to retire early increase, and employment rates of older workers decrease (see also the model simulations in the previous section). This is not necessarily efficient, and may be costly in terms of labour supply. As a corollary to Lazear (1979, 1981), binding limits on training for younger workers and compulsory OJT programs for older workers could be optimal—for a given retirement age—to avoid distortions in human capital accumulation over the life cycle if an increasing wage profile is used to provide work incentives. This is conjecture, however.

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

Monopsony

Both non-competitive labour markets and deferred payments could result in wage distributions that will not be ‘compressed’, but ‘decompressed’ over the life cycle, since earnings at the end of the life cycle increase, and those at the beginning decrease. This contrasts sharply with many modern training theories that emphasise the monopsonistic nature of labour markets (see Acemoglu and Pischke, 1998, 1999). Similar to the literature on minimum wages in monopsonistic labour markets (see Manning, 2003), this line of research essentially argues that wages are driven *below* productivity levels by firms that exert monopsonistic or oligopsonistic wage-setting powers. Consequently, firms may even pay for general training, a finding that contrasts with Becker (1964). The intuition is that productivity of workers increases faster than the wages that the firm will pay: hence, firms benefit from investing in general skills that increase the productivity of workers.

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

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

Welfare-state interventions are indeed associated with compressed wage structures (Freeman and Katz, 1995; Blau and Kahn, 1996; Gottschalk and Smeeding, 1997). Non-employment is generally higher in countries with 'compressed wage structures', in comparison with those featuring more competitive labour markets. Wages are raised above market-clearing levels in corporatist labour markets, especially at the low-end of the wage distribution and for older workers (given the much larger prevalence of non-employment among these groups). At the same time, corporatist countries with stronger labour-market regulations and more extensive welfare states have more steeply increasing age-earnings profiles compared to the countries with more competitive labour markets (Brunello, 2000; CPB, 2009). Hence, life-cycle earnings profiles 'de-compress', rather than 'compress', due to various labour-market interventions. It is therefore important to distinguish between age-earnings profiles and cross-sectional wage distributions. Cross-sectional wage distributions can indeed be compressed, but age-earnings profiles need not.

Monopsony-based theories struggle to explain unemployment, especially among the older workers. Indeed, if monopsony were the true characterisation of labour-market imperfections, then employment rates of elderly workers would be much *higher* than employment rates of younger workers (since firms extract more monopsony rents from older than younger workers because they accumulated more human capital through OJT). Monopsony-based labour-training theories could therefore be a red herring, empirically.

Specific investments

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

With specific investments in human capital, labour earnings must be higher than labour productivity at the beginning of the life cycle, and lower than labour productivity at later stages of the life cycle, if specific human capital is to be accumulated. The

intuition is as follows. Perfect competition between firms ensures that profits are driven down to zero in equilibrium. Moreover, assuming perfect mobility across jobs, the present value of earnings in a job with specific investments in human capital must be equal to the present value of a job without specific investments in order to attain equilibrium in the labour market. Thus, as long as labour productivity increases over time, the job with more investment in specific human capital pays higher wages than productivity at the beginning of the life cycle and lower wages than productivity at the end.

Empirically, it is therefore not clear whether specific investments in human capital can go a long way in explaining age-earnings profiles and relatively low employment levels of older workers. Indeed, firms would find their older workers who acquired a lot of specific human capital attractive, as they pay them less than their productivity.[8] It is also practically difficult for the analyst to distinguish specific from general training. Moreover, it is not so clear whether firms really pay for most of the costs of OJT, once the general equilibrium feedbacks in the labour market have been taken into account. Indeed, the workers may pay for the investments by accepting a lower earnings profile in a job with a lot of specific OJT investment. Most empirical analyses abstract from these general equilibrium feedbacks.

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

The empirical implications of specific OJT are similar to those of the monopsony models. Indeed, monopsony power is also driven by specificity in worker-employer relationships (Acemoglu and Pischke, 1998, 1999). Consequently, also theories on specific investments cannot explain why especially older workers would be more unemployed than younger workers.

Learning-by-doing

Wage profiles might not be generated by OJT, but by learning-by-doing (LBD). The basic idea is simple. As long as workers are employed, they accumulate work experience. Since older workers have accumulated more work experience, their productivity levels will be higher, and—in competitive labour markets—their wages will rise over the life cycle. The distinguishing feature of learning-by-doing models is that there is no trade-off between current and future earnings, as in the standard human capital models. In the

[8] Note that firms are generally not interested hiring in older workers with a high level of specific human capital acquired in other firms.

latter, working time and investment in OJT are rivalrous. In LBD models they are not; current earnings raise future earnings, as higher current earnings reflect more labour effort, which implies that there is more learning-by-doing (see also Killingsworth, 1982; Heckman et al., 2002).

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

4.3 Measurement of investment and returns

A major empirical problem in the training literature is that investments in OJT (flow) or human capital (stock) are extremely difficult to measure precisely. Neither is easily directly verifiable to the econometrician. Indeed, Heckman (2000) and Carneiro and Heckman (2003) argue that most training is informal, rather than formal. This fundamental non-verifiability of OJT investments severely limits the applicability of commonly employed training measures, which are often based on subjective data (firms or employees) on formal investment in OJT. Generally, regression analyses employ dummy variables that indicate whether workers have participated in (some) training. Moreover, the intensity of training is not always known with much precision. Further, firms and employees seem to have different views on the participation/intensity of training. See also Leuven (2005) for an elaborate review.

Not only the costs (that is, the investment in OJT), but also the returns (future wages) are difficult to measure empirically. The reason is that earnings are not equal to labour productivity—even if labour markets are perfectly competitive—, since time investment in OJT drives a wedge between gross labour productivity and gross labour earnings. This is something that is often overlooked (see, for example, Skirbekk, 2005: 16-18; Bassanini et al., 2006: 9). Clearly, time costs are the most important ingredient of investment in human capital (Mincer, 1958, 1962; Schultz, 1963; Becker, 1964; Trostel, 1993). Thus, worker productivity cannot directly be inferred from labour earnings. As a result, the returns to OJT are quite difficult to measure. Heckman et al. (1998) do obtain estimates, however, by identifying skill prices per unit of human capital from the earnings of the older workers who are in the final years of their careers. Indeed, human

capital investments would approximately be zero for these workers, so that labour earnings indeed reflect productivity.

5 Remaining gaps in knowledge: main challenges

The main question can thus be formulated as follows: how can we understand, both qualitatively and quantitatively, the life-cycle interactions between investing in human capital, retirement and pension saving? This chapter started by arguing that answers to these questions are highly policy-relevant, but that no framework is available to understand these interactions, with the exception of Jacobs (2009a) and Heckman and Jacobs (2010). These frameworks help to shed light on a number of potentially important life-cycle interactions. Although these assertions answered some questions, they also raised numerous new ones. The previous section pointed out an important number of gaps in our knowledge. To address these gaps, this final section attempts to sketch a research agenda for the future. This research agenda can be summarised as follows:

- Theory: developing life-cycle models of human capital investment in distorted labour markets;
- Empirics 1: employing structural econometrics to identify non-observable investment in human capital;
- Empirics 2: exploiting quasi-experimental evidence to identify institutional impacts;
- Data: using micro-panel data.

The remainder of this section explains the research agenda in more detail.

5.1 Theory

It is yet unknown what the most appropriate theory is for describing human capital formation and earnings over the life cycle. This chapter started from the Ben-Porath (1967) model of general OJT investments, which is firmly grounded in neoclassical human capital theory. This is a useful benchmark, given that the empirical evidence is completely in line with the predictions of the theory.

However, competing theories could provide alternative explanations for the patterns that can be seen in the data. The learning-by-doing theories are observationally equivalent from a general equilibrium perspective. Hence, it does not seem to matter much for practical purposes whether human capital is accumulated through training on-the-job or learning-by-doing. The theories on specific training and training in monopsonistic labour markets are clearly not compatible with standard human capital models. However, these theories have some predictions that are more difficult to reconcile with the data. While incentive theories (as developed by Lazear) do describe some real-world features of earnings profiles, they say little about human capital accumulation. Hence, for the time being, it seems most practical to start with standard human capital models as developed in this chapter.

Market failures and institutions are likely to be very important, but little is known on their impacts. Although some work on this has been done in static or one-shot models of investment in OJT, the literature in the field shows a completely scattered picture of the impacts of different labour market settings and institutions on OJT or life-cycle

earnings.

5.2 Structural estimation

Employing even the simplest human capital framework to analyse human capital investments over the life cycle involves a host of methodological issues and data problems. Indeed, the data are likely to remain a substantial bottleneck, because training in firms is hard to verify/measure by the analyst. Also, the returns to OJT are difficult to quantify, given the non-verifiability of investments (flows) and human capital levels (stocks).

Developing structural models appears to be the most promising—and possibly the only—route for future research. Time investment in human capital is mostly informal, and cannot, by definition, be precisely measured by researchers (Carneiro and Heckman, 2003). The estimation of structural models allows the identification of non-observables such as time invested in OJT (see, for example, Heckman et al., 1998; Heckman et al., 2002). It seems unwise to continue on the path of using very soft, noisy, and often subjective data on training efforts by workers and firms. Bassanini et al. (2006) and Leuven (2005) identify major problems with this line of research.

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

5.3 Quasi-experiments

The empirical literature has produced disappointingly little evidence on the impacts of labour-market institutions on investment in human capital. The difficulty involved in measuring costs and returns of investment in human capital is, again, one of the culprits. However, also identification problems in estimating the impact of various market structures on OJT investments are pervasive, since many of the impacts of labour market and institutional details may not be individual-specific, and may change only slowly over time. Consequently, structural methods (to identify OJT investment) should be combined with quasi-experimental evidence (due to policy changes, discontinuities in policies, and so forth) or instrumental variables to estimate the impact of institutions, labour and capital markets for the life-cycle patterns of earnings, OJT investments, saving and retirement.

5.4 Micro-panel data

Panel data should ideally be used to identify life-cycle interactions. Estimates based on cross-sectional data could be biased, since life-cycle patterns for individuals generally do not coincide with cross-sectional patterns. Moreover, panel data allow the econometrician to eliminate some of non-observed individual heterogeneity. Finally, panel data are suitable to estimate the impact of quasi-experiments.

A fundamental empirical problem is that most empirical analyses are confined to working individuals only. Hence, most data samples suffer from potentially severe attrition problems, since they do not include non-working individuals that could have been priced out of the labour market. Consequently, the identification of the impact of various labour-market imperfections and institutions could be seriously flawed. Moreover, the role of capital markets, saving and pension policies for human capital investment is a seriously under-researched area. Data collection should therefore take into account the fact that labour-market frictions may result in censored samples. However, non-employed workers need to be included for any meaningful empirical assessment of the impact of labour-market distortions and labour-market institutions.

Gathering more aggregate cross-country evidence would probably be ineffectual in gaining a better understanding of labour markets and life-cycle behaviour of individuals. Indeed, empirical cross-country analyses have produced little, if any, empirical evidence, due to limited time-series variation within countries, and large sensitivity of estimation results to country fixed effects.

6 Current state of play of European research infrastructures and networks

The main problem is that there is no 'current state of play of European research infrastructures and networks'. Various research groups operate within their own disciplines. A large group of mainly microeconomists has done extensive theoretical and empirical work on training (see the authors of Bassanini et al., 2005, and the papers they cite). However, the theoretical focus of this line of research is mainly on stylised static or one-shot human capital investment models. The empirical work is microeconomic in nature, and emphasises instrumental variables and quasi-experimental evidence. Only James Heckman and his co-authors have so far developed structural models of training in life-cycle settings (see for example, Heckman et al. 1998; Heckman et al., 2002).

Similarly, numerous researchers have also been working on retirement, with prominent examples among those participating in the project of Gruber and Wise (1999, 2002). The latter group of researchers adopts mainly a micro-econometric approach. There is hardly any theory on retirement behaviour. Retirement is often seen as a corner solution in labour-supply choices. Alternatively, retirement is modelled according to the Stock and Wise (1990) retirement-option model (for an overview, see De Hek and Van Erp, 2007). Instrumental variables, quasi-experimental evidence and structural methods are all commonly used in this literature. Some authors develop structural dynamic models of retirement and estimate them (Rust, 1989; Van der Klaauw and Wolpin, 2005; Gustman and Steinmeier, 2005; French, 2005; Blau, 2007). Human capital formation plays no discernable role in this literature.

A number of researchers have extensively analysed saving behaviour (for example, Hall and Mishkin, 1982; Hayashi, 1985; Mariger, 1987; Zeldes, 1989; Attanasio, 1995; Browning and Lusardi, 1996; Blundell, 1988). Particularly in the research group of Richard Blundell at UCL/IFS in London, a great deal of research is carried out on life-cycle behaviour in consumption and labour. Human capital formation is generally ignored in these life-cycle models of consumption behaviour.

Europe lacks a unified single research group analysing the joint impacts of labour and capital markets and institutions on the incentives for on-the-job training, pension

saving and retirement.

7 Required research infrastructures, methodological innovations, data, networks and consequences for research policy

The requirements to fully understand interactions between human capital, retirement and pensions are demanding. The policy questions raised in the introduction can only be answered by an innovative combination of theory, structural econometrics, quasi-experimental evidence and micro-panel data. Despite the high policy relevance, the complexity of all this may easily become too large, thereby hindering important results being obtained anytime soon. Theorists should develop better life-cycle theories of human capital investment that address the role of labour markets (and their imperfections), capital markets and various institutional details. Empirical economists should start to use more structural models to identify non-observable investment in human capital. They should try to develop empirical strategies to test the relevance of competing theories under different labour-market conditions. Identifying the role of institutions requires quasi-experiments. Only micro-panel data appear to be useful in order to fully identify life-cycle interactions, to obtain unbiased life-cycle profiles, and to make quasi-experimental evaluations. Cross-fertilisation between different subdisciplines in labour theory and econometrics appears to be critical, and achieving this cooperation among different research groups will be vital.

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