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Schooling as a Risky Investment

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THE CONCEPT OF HUMAN CAPITAL

The concept of human capital, so novel to many non-economists, lay already sleeping in the cradle of economics, *The Wealth of Nations* published by Adam Smith in 1776. As many treasures, it remained dormant until brought to life by two American economists, in 1945. Milton Friedman and Simon Kuznets had been asked to address the discussion on appropriateness of high incomes in the professions, such as law and medicine. They reverted to Adam Smith's analogy of education as a machine that is built to enhance production. An entrepreneur will only build (or buy) that machine if the capital invested generates a sufficient rate of return. Friedman and Kuznets interpreted the level of income earned in the professions as a return to the investment that had been made for the education earlier in life, and indeed found that by that standard incomes were not excessive. During the 1960's, American economists started to develop the full implications of this approach. In 1992 Gary Becker, from the University of Chicago, was awarded the Nobel Prize in economics for his fundamental contributions in this field. By now human capital is indeed a household concept, and the term social capital has been coined in an attempt to copy its success.

One might define human capital as the value of knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity. The focus is sometimes restricted to the value of those skills and productive capacities that people have had to acquire at a cost, to focus on investment characteristics. This would then exclude innate abilities that people are born with, as endowed human capital, a free gift of nature. It is also possible to use a broad concept of human capital, not necessarily considering only the sales value of improved skills, but also including the private valuation of greater consumption. Schooling may not only raise your market value as an employee (or employer), but may also increase your enjoyment of literature, music and culture in general. Human capital in this broad sense might then be valued as the cost of all actions taken to increase future welfare.

Applying the perspective of investment in human capital has been very fruitful to understand many choices that individuals make and to analyse social consequences and options for economic policy. This in no way conflicts with the view of schooling as one of the most rewarding activities in a person's life, as a way to open up new worlds, a route to intellectual, artistic and social development that matches an individual's abilities and interests and that by itself can generate sheer joy. But few things in life are really free. Even individuals with an insatiable intellectual appetite will have to devote time and other resources to education that might have been spent on other pleasures. The outcome of such comparisons may be obvious to them, for many others schooling will be a cost that precedes benefit. Not everyone will engage in an education only for the immediate pleasure of the intellectual process itself. Expected benefits will play an important role in their decisions. Even members of the Academy will not have lived in intellectual ecstasy in every stage of their education.

This contribution will focus on schooling as a risky investment, that is, an investment with uncertain pay-offs. This will be done in the framework of human capital theory. Attention will be restricted to benefits in terms of income, thus ignoring other benefits without in any way denying their importance. The paper first presents a brief and basic view of the human capital model of schooling, and then considers the risk aspects of such investment. Without apology there will be disproportionate attention for my own research. But it is only fair to mention that many others have contributed to research on income distribution and the role of education in general and on the situation in The Netherlands in particular (Tinbergen, 1975: Pen, 1971; Fase, 1969; De Wolff and Van Slijpe, 1973; Ritzen, 1977).

THE BAREST MODEL OF INVESTMENT AND SCHOOLING

Figure 1 shows the barest possible analysis of investment in schooling. A person faced with the decision to embark on studies requiring s years of full-time attendance knows that after these s years he will earn an annual wage of W_S, from s until retirement at age 65, or, more generally, at age T.

His alternative is not to study, go straight to work and earn W_O from the time of decision until retirement at time T. Going to school has an annual cost for tuition and books of K.

Note the strong simplifications: there is no (ability) restriction on entering school, no failure or drop-out risk, earnings are constant throughout working life, independent of work experience, known with certainty, and there is no risk of unemployment. The human capital model allows to deal with the associated complications, but we will not treat them here. The basic framework can be used for three types of analysis: we can analyse investment decisions, we can calculate the rate of return on an investment, and we can predict the equilibrium structure of wages by level of education.

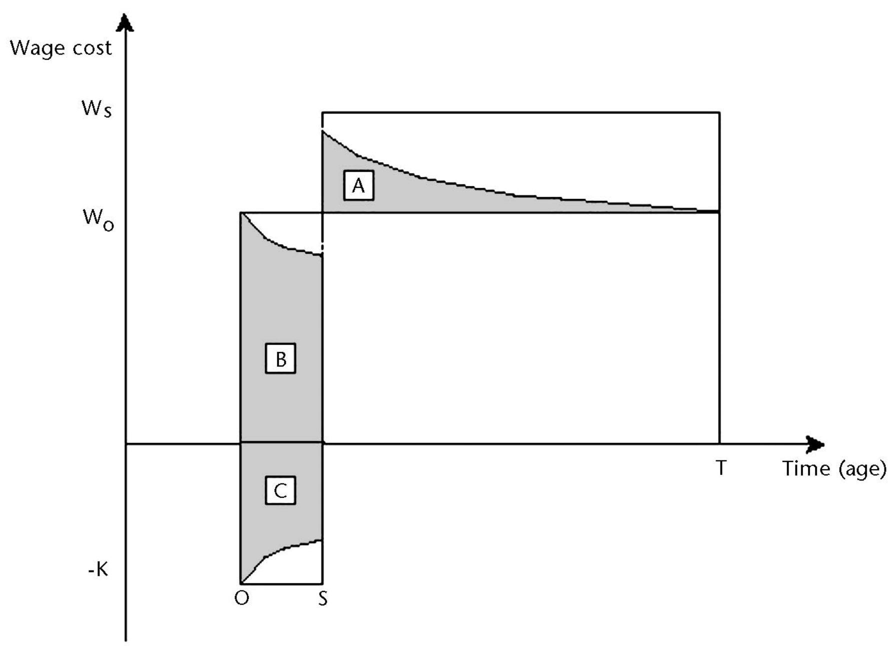


Figure 1 Human capital as an investment

The investment decision
We can analyse the decision whether or not to go to school by simply comparing the total lifetime discounted[1] income from the two alternatives and choosing the alternative with the highest lifetime discounted income. We can also subtract income in case of no schooling from income in case of schooling and predict that the individual will go to school for s years if the balance is positive. In the first s years the gap is $-K-W_O$ per year: the individual has to pay K for tuition and books and does not enjoy the income from working W_O. The latter, W_O per year, is called the *opportunity cost*, the income forgone by choosing the other alternative. W_O+K is the annual investment cost. In a lifetime perspective, after discounting, it is indicated by the shaded area in Figure 1 (B+C). After s years, the difference between the two income streams changes sign: earnings W_S surpass no-schooling earnings W_O. The difference W_S-W_O is precisely the benefit from schooling, the higher annual wages due to schooling. Again, taking off the edges by discounting, we see the contribution to the lifetime earnings difference as the shaded area to the right of s (A). Now, the decision rule is simple. The person will go to school if the lifetime earnings balance from the schooling alternative is positive, or if the lifetime benefit (W_S-W_O, from age s to age T, discounted) is larger than the investment cost ($K+W_O$, from age 0 to age s, properly discounted). If people could borrow and lend at one and the same rate of interest, this rate would be the proper discount rate. However, this is often not the case. The wage gain is usually discounted at the person's own discount rate, rather than at the interest rate in a perfect capital market (What is, in *your* assessment, the value right now of the euro that you will receive next year?).

This very simple model already has some interesting conclusions. First, we may note that investment cost, the cost of going to school, consists of direct cost K and opportunity cost W_O the wage that might have been earned. It is often not realised that foregone earnings are by far the biggest cost component. Tuition of less than 1500 euro per year for a university education, as is presently the case in The Netherlands, dwindles by comparison to an annual income of perhaps 30 000 euro that might have been earned with a secondary education diploma. Quite often, the direct outlay for tuition and books is no more than 10% of the opportunity cost, the wages that are lost.

[1] A euro earned after one year is not the same as a euro in hand right now. If a person values a euro next year at 0.9 euro now, the discount rate is 10%. Discounting is reflected in shrinking values further in the future, as indicated by the sloping borders of dashed areas.

Second, we can make some immediate predictions. Participation in schooling will increase if:

- future benefits increase, i.e. the wage premium for those who have completed their education is raised
- direct cost of education decreases, because schools lower tuition or the government subsidises schools
- the discount rate decreases, as the weight of future wage gains increases relative to cost in the earlier career stage (or, stated otherwise, those with an orientation towards the future rather than towards the present, i.e. with a lower discount rate, are more inclined to embark on schooling)
- financing education becomes easier. Banks may become more inclined to provide funds, parents may become richer and have more funds available in a process of economic growth, the bank lending rate may drop or the government may provide cheap loans, or even free scholarships.

All these predictions have been supported by empirical evidence, although magnitudes of effects may sometimes be small.

Optimal investment in schooling

With schooling as a sequential process, and some individuals acquiring more schooling than others, it is only natural to wonder about the optimum length of schooling. While the returns to investment have been analysed in similarity to return to investment in physical capital, with schooling compared to building a machine, the problem of optimal schooling length has a much fancier analogue: it ‘s a problem of optimal stopping, similar to the optimal time to cut a tree in a nursery or to sell (or drink) the wine that was maturing in the cellar. Students maturing like wine, no doubt a metaphor that pleases educators. The full implications of that view, for the proper mathematical modelling, have only recently been appreciated (see the references in Bajdechi, Hartog and Van Ophem, 2004) and we will not pursue that approach. Here, we only give a simple exposition based on a preset lifecycle plan, rather than on sequential decision making. In the preset lifecycle plan, young individuals decide on the optimum length of education and then follow their plan. In sequential decision making, individuals permanently consider whether to continue education or to quit and go to work, based on new information that continuously arrives.

For each additional year of schooling, there will be an increase in lifetime earnings but most likely it will not be constant. Initially, the increase in lifetime earnings may get larger if one continues to add years of schooling. Building on prime skills like writing, reading and basic arithmetic may generate increasing benefits. But after some stage, declining marginal benefits for additional years spent in school are inevitable. There is a limit to what one can profitably learn in school. Moreover, with additional time spent in school, remaining working life is shortened and this reduces the time to reap the benefits. We will suppose that the range of declining marginal benefit is relevant. We suppose also that the cost of an extra school year will increase if one keeps on extending the schooling period. An immediate reason for this increase is the higher opportunity cost. The longer one has been in school, the higher the wage one may earn with that level of schooling. Not going out to work then simply becomes more expensive.

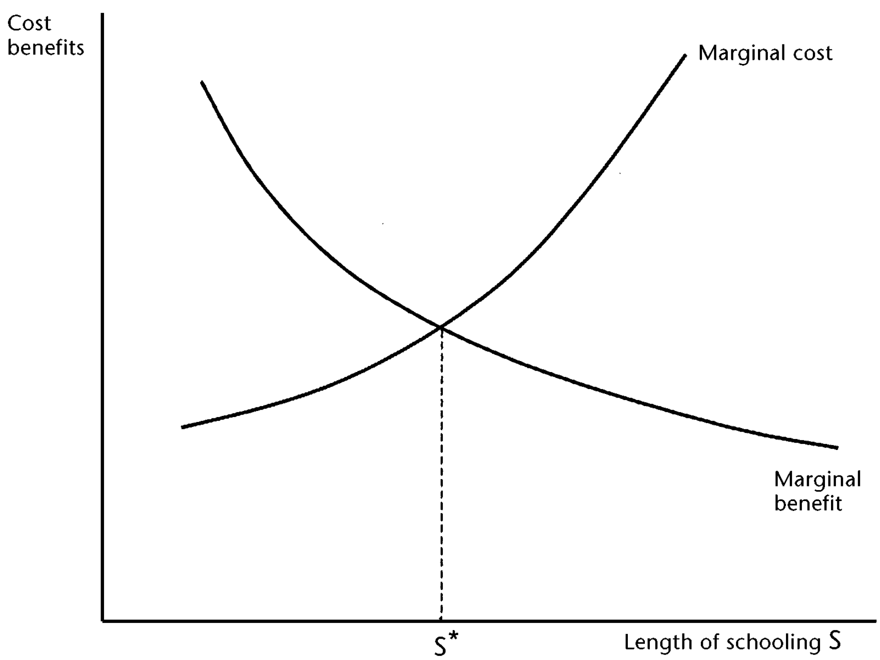


Figure 2 Cost and benefits of schooling

We can now draw a picture like Figure 2: if schooling is extended and extended, marginal benefits (for an extra year of schooling) will fall and marginal cost will increase. The optimum level of schooling occurs at the intersection of marginal benefit and marginal cost. Increasing beyond S* would generate more additional cost than additional benefit, and hence would not be rational. This framework has also been used to derive some predictions, mainly by allowing the cost and benefit curves to differ between people:

- Persons with a lower marginal cost curve will invest more (stay in school longer). One cost element is the cost of funds, the borrowing rate. Wealthier families have cheaper access to funds and send their children to school for more years. If cost includes psychological costs (or pleasures of learning, as negative cost), those with more intrinsic interest in schooling opt for longer schooling.
- Persons with higher marginal benefit curve will invest more. Suppose family networks are important in placing you in the right job after school. Then families from the higher social strata have children who study longer. It is also conceivable that persons with higher academic ability or IQ benefit more from schooling, as schooling is complementary to their talent. This would lead them to study longer. However, abler people presumably also have higher opportunity costs. (If you're so smart why are you still in school, was the title of a paper some decades ago.) On average, abler individuals stay in school longer, so apparently the first effect dominates the second. But direct evidence, on complementarity between ability and benefits from schooling, is mixed (Hartog, 2001).

The rate of return to schooling

The framework can be used to calculate the rate of return to investment in schooling. Given the investment during the schooling years, to what annual rate of return does the wage premium W_S-W_O correspond? The internal rate of return is the discount rate that exactly equates the present value of lifetime investment cost and lifetime wage gains, i.e. the two shaded areas in Figure 1. To calculate this, one should know a person's realised earnings during his lifetime and wait until retirement. In practice, the rates are estimated from wage equations, assuming an equilibrium structure (see below).

Rates of return to education have been calculated abundantly, for many times and places. George Psacharopoulos is the great *collectionneur* of such studies (Psacharopoulos, 1994). His results, unweighted, not conditioned by methodology or quality of the estimation, suggest some general tendencies:

1. Private rates of return are higher than social rates of return. Private returns relate the person's after-tax earnings gain from education to the person's cost, social returns relate gross earnings gains to actual social cost, irrespective of government subsidies to schools and students.
2. The rate of return varies by level of education. The highest returns relate to primary education: learning how to read, write and do arithmetic are the most profitable investments. There are some signs that the relation for private returns may be U-shaped, with a somewhat lower return for intermediate schooling levels.
3. The rate of return diminishes by level of development of the nation: highest rates are found in developing countries.

In an international project funded by the EU, the available datasets in 15 European countries are used to generate an overview of private returns as they have evolved over the last two decades. The project emphasised the application of a common methodology, to comparable datasets. The average rate of return to a year of schooling in 15 EU countries has been estimated at 6.3% (Asplund and Pereira, 1999). Between countries, estimates range from 4.5 to 9%.

Remarkably, there are just a few studies to explain differences in returns between countries: explaining international differences is not a developed research area. It's easy to think of potential explanations, though. One may expect rates of return to relate to labour market and wage setting institutions, school systems, tax systems, subsidies to education, often in predictable ways, but such relations have not been seriously tested. There is evidence that rates of return tend to follow shifts in supply and demand (Leuven, Oosterbeek and Van Ophem, 2004). It is often alleged that wages are set by institutional arrangements and not in open flexible labour markets. Nevertheless, returns to education appear to fluctuate in response to supply and demand conditions, as will be illustrated below.

The wage structure by level of education

Suppose everyone had equal ability to benefit from education at any desired level and everyone was only interested in maximising lifetime earnings. In that case, everyone would decide to follow just the education that promised the highest lifetime net earnings (net of schooling investment cost). We would then only observe people in each and every education if lifetime net earnings were identical for each education. The rate of return to the investment would be equal in all educations. The equality could be established by flexible wages. If too many people follow a particular education, they would invade the labour market and the wages for graduates with that particular degree would drop. Similarly, if few people graduated from that education, shortage would increase their wages. Only if wages generate equal lifetime earnings could we have an equilibrium.

Applying simple mathematics to this line of reasoning generates very elegant formulae (see Appendix). A key result is the so called Mincer earnings equation, after the US economist Jacob Mincer who developed the method: every extra *year* of education generates a specified *percentage* increase in wages (Mincer, 1974). This percentage increase, say 5% or 10%, for an extra year of completed education is then the return to education. A highly simplified intuitive argument may help. Suppose there were no discounting. Then, if you go to school for 5 years, and hence forego five years' wages, and you have 40 years to make up for the loss, raising the annual wage for the educated by 5/40 = 12.5% precisely makes up for it. Discounting future earnings changes the numbers, but does not affect the essence of the arithmetic. Note that in this approach wages increase with schooling because they compensate for the earnings forgone while in school: it's the reward for waiting for earnings to start flowing.

In practice rates of return to schooling are estimated by employing the equilibrium wage equation (see Appendix). If in equilibrium wages are determined as a given percentage increase for every extra year of schooling, we can estimate the return by regressing wages on years of schooling. More precisely, the rate of return is estimated as the regression coefficient of the logarithm of wages on years of schooling. But note that the interpretation of this regression coefficient as a return on the investment only holds under very restrictive conditions.

DEALING WITH SOME COMPLICATIONS

A bare model has the virtue of showing the essentials, but is subject to the immediate criticism of ignoring important features. Three complications in estimating returns to education will be briefly discussed.

Omitted variables

Individuals differ in many aspects, such as intellectual ability, motivation, interests, etc. These factors will blur the estimates of rates of return to education. Higher wages for individuals with more schooling will not only be caused by what they learnt in school but also be due to their abilities and other characteristics. Allowing for direct measures of intellectual ability (such as IQ) tends to reduce the measured rate of return to education by roughly one third. Allowing for measures of personality has a very modest effect (Hartog, 2001).

Cross-section estimate
Rates of return are commonly measured from a cross-section sample of individuals, allowing for the effects of age, experience and possibly tenure. But this assumes that the effect of education is the same for those who graduated 10, 20 or 30 years ago. There are many reasons why this may not be true. The composition of the graduate population 10, 20 or 30 years ago may be quite different, in terms of unmeasured qualities. The schools will have changed, in organisation, differentiation and curriculum. And different cohorts will have different labour market experiences, which may have lasting effects on the benefits from their education. Heckman, Lochner and Todd (2003) is one of the very few studies paying attention to these issues. They find substantial differences between cohort and cross-section estimates, with under- and overestimation depending on the characteristics of the individuals.

Selectivity
Individuals are not randomly distributed over education levels and we cannot estimate the 'treatment effect' (of a given education) as not being affected by systematic differences between the 'treated' and the 'non-treated' unrelated to the expected benefit. Typically, individuals will make a deliberate choice on the length (and type) of their education, as analysed above. It is not clear in what direction this will bias estimated returns. One may assume that individuals with high potential benefits will be more inclined to opt for longer schooling and those with low potential benefits will leave school at an early age. This will lead to an overestimate of the returns for an average individual. But it is also conceivable that long educations are taken by individuals with low cost (as e.g. students from wealthy families), pushing them into educations with low marginal benefits (see Figure 2). The problem is acute because of incomplete observation. We observe post-school earnings for individuals who have taken this education, not what they would have earned had they not taken the education. Conversely, we do not observe post-school earnings for individuals who have not taken this education, and hence we cannot observe what their benefits might have been. There are econometric techniques to deal

with these issues. However, the resulting estimates are not very robust, and very sensitive to specification of the econometric model (Card, 1999; *Labour Economics* Special 1999).

Of course, there are many other complications and relevant refinements, such as dealing with the details of the school system, admission standards, etc, but they will not be discussed, as the focus is on issues related to risk.

VARIABILITY, VARIANCE AND RISK

An individual deciding on education is confronted with several uncertainties. First of all, the potential student will have very imperfect information on the education itself. Most schooling systems confront students with an increasing array of choices as they advance in their schooling career. Whereas at the elementary level usually the curriculum is fixed and identical for all pupils, at some point after basic education students have to decide on the type of school they will attend next and on the type of curriculum within those schools. After completing secondary school, they may attend university education, where the number of options, between disciplines and curricula within the disciplines, is even larger. In a Danish dataset our original data distinguished 1750 educations. There is a very nice illustration of imperfect information from the novelist Maarten 't Hart, who thought that a single day in school would teach him how to read and who was very disappointed when this turned out to be a false expectation ('t Hart, 1978, p 11). Perhaps even more telling is the series of schooling choices made by Paul van der Hoeven, who ended up as a famous Hollywood movie director: 'I did theoretical physics, but it was so hot in the lecture hall, and so crowded and a drill outside made so much noise that I left during the break and never returned. I switched to mathematics, and then started to make movies.' (interview in NRC, August 27, 2004). Clearly, potential students do not know what the programmes exactly entail, whether they will like them or not, and whether they will be able to fulfil the requirements (whether intellectual, or plain patience or the ability to withstand noise and heat) to complete any given programme.

Second, after graduating from some programme, the student faces a similar uncertainty in the labour market. Even being educated for some trade or profession, she may lack the ability or other requirements for success. Or, stated more generally, she does not know where in the distribution of occupational competence and earnings she will end up. There may be a wide dispersion of performance or productivity in the occupation and the individual may not know her true competence when entering the trade. Adam Smith, as far back as 1776, was well aware of this: '*The probability that any particular person shall ever be qualified for the employment to which he is educated is very different in different occupations. Put your son apprentice to a shoemaker, there is little doubt to his learning to make a pair of shoes; but send him to study the law, it is at least twenty to five if ever he makes such proficiency as will enable him to live by the business'.* (Smith, 1776, 208). There are obvious consequences of such dispersion. Rather than comparing given (or expected) wage rates for different educations, an individual deciding on a schooling career faces a choice between different distributions of earnings, as illustrated in Figure 3. If the individual will go straight to work, he will face the distribution centering on expected wage W_0, if he first attends school he will face the distribution centering on W_S. Clearly, the nature of these distributions will have an impact on his choice.

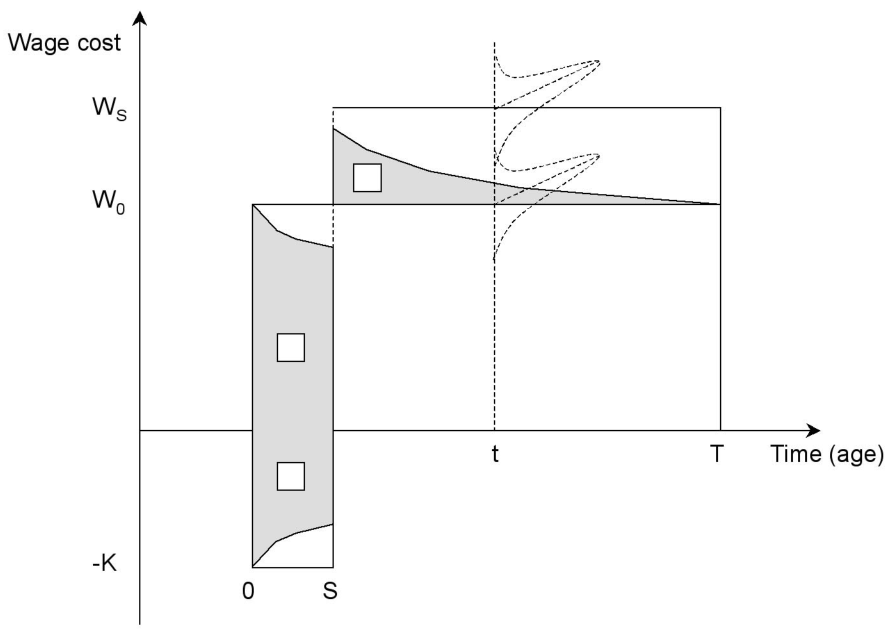


Figure 3 Education as an investment under risk

On top of uncertainty about future position within a particular occupation, there is uncertainty about future market value of the entire occupation itself. There may be cyclical fluctuations, as for *chefs de cuisine*, and there may be structural fluctuations, such as associated with jobs moving to the world's low-wage regions or the emergence of completely new jobs.

No doubt, students making their choices have at least some minimal awareness of the risks, and will take these into account when comparing the alternatives. Kodde (1985: 56) surveyed secondary school graduates and asked for their expected earnings from pursuing a university education, and the maximum and the minimum of the earnings they anticipated from continued education. On average, there was a 90% gap between maximum and minimum earnings, with a standard deviation of almost 40%.

Considering the pervasiveness of risk in schooling decisions, it is remarkable that standard human capital analysis for so long has mostly ignored the issues. The existence of risk has implications for schooling choices, for impact of differences in curricula, and for the operation of the markets for educated labour. There are important policy consequences, for the design of schooling systems and for financing education, in particular for financial support for low-income students. Only recently is academic research beginning to respond to the challenges. We will summarize the literature, and highlight our own contributions, on four issues: educational choice under risk, information on risk by education, dispersion in rates of return and risk compensation in wages.[2]

Earnings variance by education

We noted that risk involves choosing an education for which one does not know for sure what earnings this will generate; rather, it gives access to a distribution of earnings. Thus, an obvious first step in dealing with the financial risk of an education is to consider how the distribution of earnings varies with education: we will assess the dispersion in the distributions illustrated in Figure 3. We can then check whether individuals with more advanced education move into wider or narrower earnings distributions.

By itself dispersion is not sufficient information on individuals' risk. We should make a distinction between risk and heterogeneity. Risk occurs when a decision maker does not know the value of a variable or a para-

[2] The risk of dropping out of school before obtaining a diploma is also relevant and there is a literature dealing with it (see Montmarquette et al, 2001). However, as we have made no contributions, we will not dwell on the issue.

meter with certainty, but only as a probability distribution. Heterogeneity refers to differences between individuals in relevant characteristics that individuals know but researchers don't. Earnings will depend on individual abilities, personality traits and schooling. Suppose an individual would exactly know her abilities and personality traits. Conceivably, from observing the labour market, she might then know exactly the earnings effects of her abilities, and she might observe what, with her abilities, she will be able to earn under the present market conditions, with different levels of schooling. If we observe the earnings distribution for individuals with given levels of schooling, but we do not know the abilities and motivations, we cannot condition earnings on these abilities and motivations. The dispersion we observe is then the effect of individual heterogeneity; and it is not a measure of individual risk. We may assume that in general individuals are not fully informed about their abilities and motivations. This means that observed dispersion is a mixture of individual heterogeneity and risk. We would expect that observed dispersion overestimates risk, as it ignores the better information that individuals have.

It's a challenge for empirical research to disentangle heterogeneity and risk. From our perspective this means finding out what individuals know when they have to take their decisions and how well they know it. Typically, our knowledge of individual information is quite limited. Some economists argue that individuals have much better information on their future situation than the researcher has. There are good reasons for strong doubts about this assumption. Webbink and Hartog (2004) compare starting salaries that first year university students expect upon graduation, and the realised starting salaries, just some four years later. The joint frequency distribution of these two individual salaries is given in Figure 4. For a given expectation, there is a wide distribution in realisations; expectation and realisation correlate at only 0.06, indicating that individuals cannot predict where in the earnings distribution they will start their career. Information like in Figure 4 is rather scant, and there is in fact no solid evidence about the information that individuals use when making up their minds on education, as economists put their faith mostly in 'objective' variables and tend to discard subjective information, perceptions, etc. This must be considered a serious error: inevitably, individual decisions will be based on individual's perceptions.

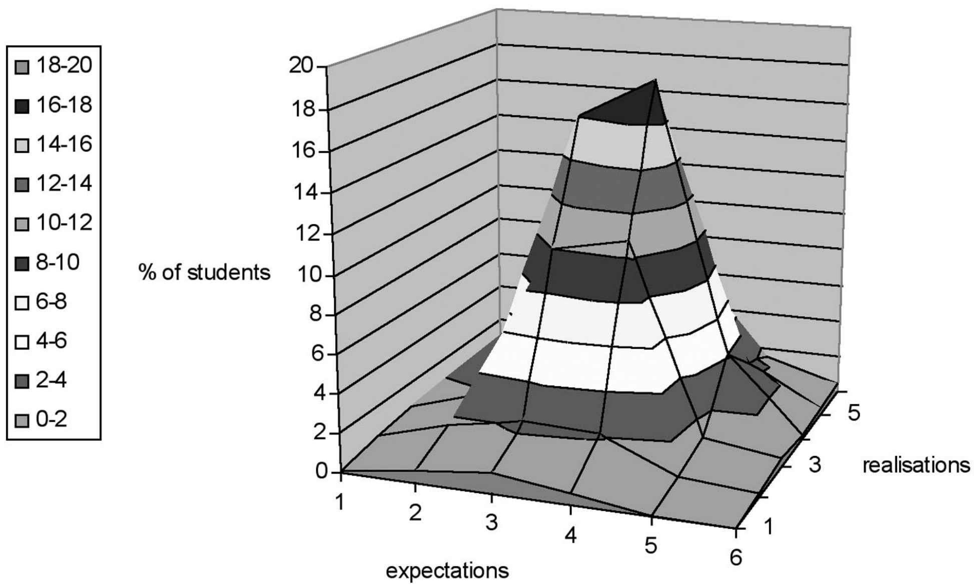


Figure 4 Expectations and realisations of earnings at the individual level (interval size one standard deviation) Source: Webbink and Hartog, 2004

Table 1 presents a summary of results on earnings variance from a scan of the literature. Comparing earnings variance by level of education is not an established research topic, so we could only collect what happened to be available in studies undertaken with a different purpose. The table indicates that there is no standard pattern. Thus, to formulate our conclusion in a precise way: if we compare earnings distributions for individuals with different levels of education, we can neither say that individuals with longer educations are always found in wider distributions nor that they are always observed in narrower distributions. In Hartog, Van Ophem and Bajdechi (2004a) we have measured dispersion in a standardised way, applying the same specification to comparable datasets for seven countries, with the same result: there is no uniform relationship between earnings dispersion and schooling level across countries.

Table 1 Earnings dispersion by education and experience (age).

Author	Country and Sample	Year of the sample	Measure of Income Variation	Education
Becker	U.S. college & high-school	1939, 1949	c.v.	+
Weiss	U.S. scientists	1972	c.v.	-
Hartog	Netherlands	1962, 1965, 1972	c.v.	∩
Chen	U.S. college & high-school	1979-1998	c.v.	+
Hartog et al.	Netherlands	1962, 1965, 1972, 1979, 1985, 1989	σ(lny)	+
Polachek	U.S.	1980, 1990	σ(lny)	+
Polachek	LIS countries	1990	σ(lny)	0
Belzil & Hansen	U.S.	1979	σ(lny)	-

Notes: lny for log wages; c.v. for coefficient of variation; ∩ for inverse-u-shape; + for positive, - for negative, 0 for no clear positive or negative effect of education level on dispersion. Source: Hartog, Van Ophem and Bajdechi (2004a)

Variation in returns over time

As noted, the rate of return to education can be estimated from a Mincer earnings equation. Repeated estimates of Mincer equations over time show variability of returns to education over time. The returns will not stem from repeated draws of a stable underlying distribution, as in a lottery. But surely, the data will tell us something about the magnitudes of some relevant variability.

Using a succession of datasets, we have estimated Mincer rates of return in The Netherlands from 1962 to 2001 (Hartog and Oosterbeek, 2004). The estimates are reproduced in Figure 5. The substantial drop in the returns to education between the early 1960s and the mid 1980s can be attributed to an equally substantial increase in the supply of educated labour. In 1960, 57 percent of the male labour force had only basic education and 4 percent had a (semi-)higher education degree. In 1979 22.9 percent had just basic education and 13.6 percent had a (semi-)higher education degree. For women, these figures changed from 54 and 1 percent to 20.5 and 11.9 percent. Although the increase in education levels of the workforce has continued, we observe a stabilisation of the returns to education between 1985 and 1995 and a fairly rapid increase after 1995. This pattern is commonly explained by changes at the demand side. Skill biased technological change (increasing demand for the higher educated) and changes in the international trade patterns (decreasing demand for the lower educated, as their jobs are moved to low wage countries) are often mentioned as forces causing stronger demand for high skilled workers relative to low skilled workers (with the technology explanation most convincing, as the widening wage structure is not restricted to industries with much import). Hence market forces seem largely responsible for increased earnings inequality between educational levels within the Netherlands (cf. Hartog, Oosterbeek and Teulings, 1993; Leuven and Oosterbeek, 2000). An interesting example is also provided by Sweden (Edin & Holmlund, 1993). The greater supply of university graduates lowered the rate of return to education. However, after a while, students reacted to this decline in returns with a reduction in university education, and the rate of return increased again.

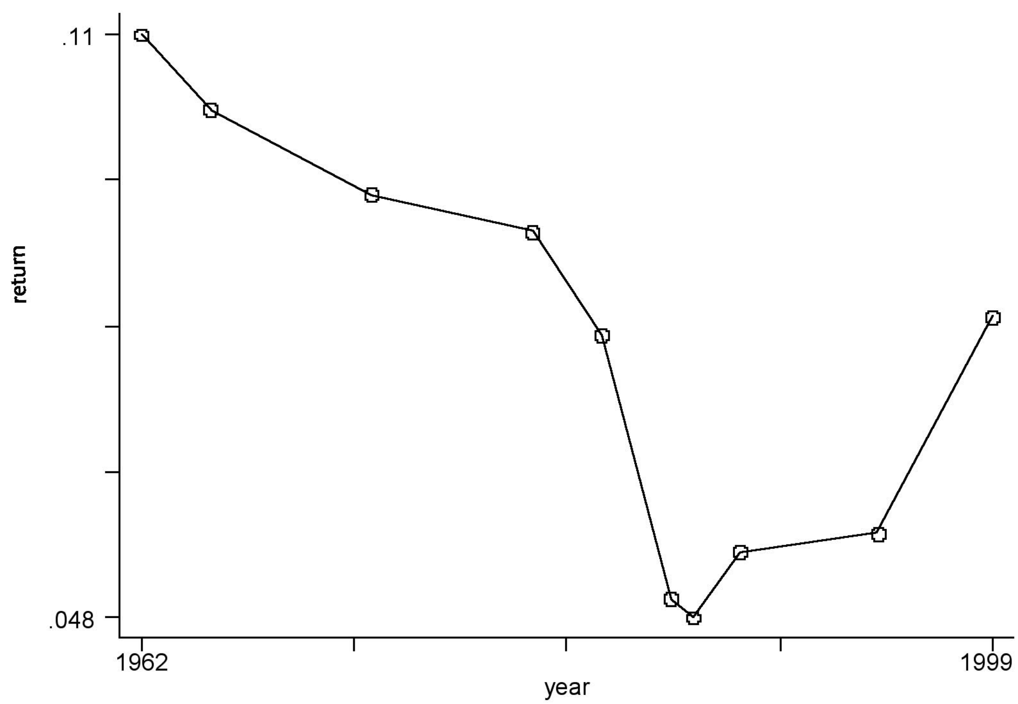


Figure 5 Mincer estimates of return to schooling for the Netherlands, 1962-1999 males
Source: Hartog and Oosterbeek (2004)

Dutch experience differs from that of the USA, the UK and Australia where the return to human capital already increased markedly during the eighties. In the U.S., Finis Welch (Willis, 1991) estimated a set of cross-sectional statistical functions using micro data from the March CPS Surveys from 1968 through 1983. The rates of return to college education stayed within a narrow range of 8 to 9 percent during the entire period from 1967 to 1981 and rose to little over 10.2 percent in 1982. Heckman, Lochner and Todd (2003) find a modest variation of Mincer returns for white men between 1940 and 1990 (between 10.2 and 12.9 percent); for black men, the variation is larger, with the return increasing from 8.7 percent in 1940 to 15.2 in 1990.

Variation across countries and studies

The project PURE (Public Funding and Private Returns to Education; Harmon, Walker and Westergaard-Nielsen, 2001) generated private returns to education across Europe from comparable datasets and a uniform methodology. The relative magnitudes of returns over the years differ very much from country to country. In Austria and Sweden the trends are downward with about 3%, whereas in Denmark, Netherlands, Portugal, UK, Ireland and Italy they are upward trended (Table 2). The returns in Germany, France, Norway, Finland, Spain, Switzerland and Greece indicate no obvious trend. The project finds that minimum rates over the sample period varied between countries from 4.0 to 10.7, while maximum rates are between 6.2 and 11.5 percent.

Trostel, Walker and Woolley (2002) use data for 28 countries covering the period 1985-1995, from a common questionnaire applied in all countries. Averaged over the 28 separate country estimates, the mean return is 5.8 percent for men, with an unweighted standard deviation of 3.5 percent. For women, the mean return is 6.8 percent, with standard deviation 3.9 percent.

We may conclude that repeated estimates of Mincer equations over time, within a country, show clear variability of returns to education. This provides some indication of the risk that is associated with shifting market value of schooling, as a consequence of changes in supply and demand conditions. But since the estimates are usually taken from cross-sections, they have limited value for specific cohorts. In fact, shifts in the mean market value of schooling are probably underestimated if they are taken from cross-sections, simply because they are averaged over cohorts.

Table 2 Variation in rates of return over time and country.

	Minimum Rate of Return to years of schooling and the corresponding year	Trend	Maximum Rate of Return to years of schooling and the corresponding year	Gap
Austria	0.074 (1997)	↓	0.103 (1981)	0.029
Sweden	0.040 (1991)	↓	0.075 (1968)	0.035
Denmark	0.044 (1982)	↑	0.061 (1995)	0.017
Ireland	0.097 (1987)	↑	0.115 (1995)	0.018
Italy	0.039 (1981)	↑	0.062 (1995)	0.023
Netherlands	0.058 (1986)	↑	0.063 (1996)	0.005
Portugal	0.107 (1982)	↑	0.109 (1995)	0.002
U.K.	0.049 (1980)	↑	0.065 (1995)	0.016

Source: Harmon et al. (2001)

We can also infer variability of the rate of return from the variation across studies. An accessible overview of such studies is given in the meta-analysis performed by Ashenfelter et al (1999). They analyze 96 returns to schooling obtained from 27 studies covering 9 countries. Across all these estimates, the mean return was estimated at 0.079 with a standard deviation of 0.036.

Variation across individuals

Harmon et al. (2003) extend the standard human capital earnings function to include dispersion in the rate of return to schooling. Their estimation model allows the return to education on a sample of U.K data to vary across individuals (a random coefficient model). They find that neither the mean nor the dispersion in the returns to education have altered significantly over time. For men, they estimate mean returns of about 4%, at a dispersion of also 4%. Assuming a normal distribution, 95% of men have returns in the – 4 to + 12% interval. Thus the dispersion is large even though differences in observable characteristics between individuals have been taken into account.

Table 3 Average Return to Education (OLS), and Difference in Returns between the Lowest and Highest Decile (Quantile regression).

Country	OLS	10th percentile	90th percentile	*Difference*
Austria (1993)	9.7	7.2	12.8	5.6
Denmark (1995)	6.6	6.3	7.1	0.8
Finland (1993)	8.9	6.8	10.1	3.3
France (1993)	7.6	5.9	9.3	3.4
Germany (1995)	8.0	7.5	7.8	0.3
Greece (1994)	6.5	7.5	5.6	-1.9
Ireland (1994)	8.9	7.8	10.4	2.6
Italy (1995)	6.4	6.7	7.1	0.4
Netherlands (1996)	7.0	6.3	8.3	2.0
Norway (1995)	6.0	5.5	7.5	2.1
Portugal (1995)	12.6	6.7	15.6	8.9
Spain (1995)	8.6	6.7	9.1	2.4
Sweden (1991)	4.1	2.4	6.2	3.8
Switzerland (1995)	9.5	8.7	10.6	1.9
U. K. (1995)	8.6	4.9	9.7	4.8
U. S. A. (1995)	6.3	3.9	7.9	4.0

Source: Pereira and Martins (2001), p. 8

Pereira and Martins (2001) aim specifically for risk and propose to measure this as the difference in returns between the top and the bottom of the wage distribution (from a quantile regression estimation of the Mincer equation). The idea is that if you do not know whether you will end up at the bottom or the top of the distribution, the gap in returns between top and bottom is an indication of your risk. Pereira and Martins's results are presented in Table 3. The risk lies between –1.95% and 8.9%, at an average unweighted OLS return of 7.8 percent.

Simulating the rate of return

The risk associated with investing money in a particular stock can be assessed by inspecting the variation in the returns over time: observations on dividends and stock prices can be used to calculate historical (ex post) rates of return per time period and their dispersion. But we cannot characterise the risk of investing in schooling from direct observation. For any given individual we can at best observe actual earnings during working life associated with the chosen education (if the period of observation is long enough). But we will never have observations on the earnings that the individual would have obtained without the education and thus we cannot observe the benefits from schooling directly. Therefore, we have turned to simulating this process (Hartog, Van Ophem and Bajdechi, 2004). We modelled a situation where an individual can directly go to work, and obtain a flow of annual incomes from now until retirement, or go to school and only starts earning after graduation. We assume both incomes to be stochastic: in every year there is a random shock to income (we use an AR(1) process). In the simulation, we specify the probability distribution from which the annual shocks are drawn, the correlation of individual shocks over time and the correlation between the shocks for earnings with and without extended education. For each of the alternatives (school and no-school) we draw earnings for each year (age) until retirement, from the given probability distributions. As stated earlier, the return to education is defined as the internal rate of return. We calculate this return, as the discount rate that equates the present value of the two income streams (school, no school). We repeat the process 100 000 times for given parameter specifications (to reflect the randomness of the draws) and then calculate mean and standard deviation of the rate of return. Parameter values are based on a search of the empirical literature. Only the correlation between shocks in the alternatives (school, no-school) is never observed and simply had to be assumed.

Figure 6 gives results for a characteristic case ('density' on the vertical axis can be understood as relative frequency). We immediately observe two conclusions. First, for realistic values of the parameters we have not found negative returns to education: in our simulation you never loose money from going to school. Second, the distribution of returns is asymmetric: the upper tail is longer than the lower tail. Higher upside risk than downside risk is generally something that individuals appreciate, as we will discuss below. Our results show that the dispersion in the rate of return depends on the sum of the dispersions in the two alternative earnings profiles (school, no-school). Thus, increasing dispersion in any of the two careers increases the rate of return. The dispersion in returns responds negatively to the correlation in the shocks between two alternatives. With negative correlation, a high shock to earnings with additional school tends to go together with a low shock to earnings without schooling: negative shocks for schooled earnings on average would have been absorbed without schooling. Conversely, with positive correlation, shocks tend to move in tandem: an unexpectedly high schooled wage in some year would also, on average, have meant an unexpectedly high income without schooling, in that same year. In other words, with positive correlation schooled and unschooled workers experience similar risks, whereas with negative correlation the income fluctuations go in opposite directions. Clearly, with positive correlation the dispersion in the rate of return is low, as shocks affect both incomes in the same direction, with negative correlation the two incomes diverge, and the dispersion in the return increases. If the correlation moves from +1 to –1, the dispersion in the rate of return doubles.

The final conclusion answers the key question: how risky is investment in schooling? The coefficient of variation in the rate of return to education, for most plausible values of the parameters is about 0.25 (i.e. the standard deviation is about one quarter of the mean). This makes investment in schooling about as risky as investing in a portfolio of 30 randomly chosen stocks on the New York Stock Exchange, based on stock returns known in 1970 (Fisher and Lorie, 1970).

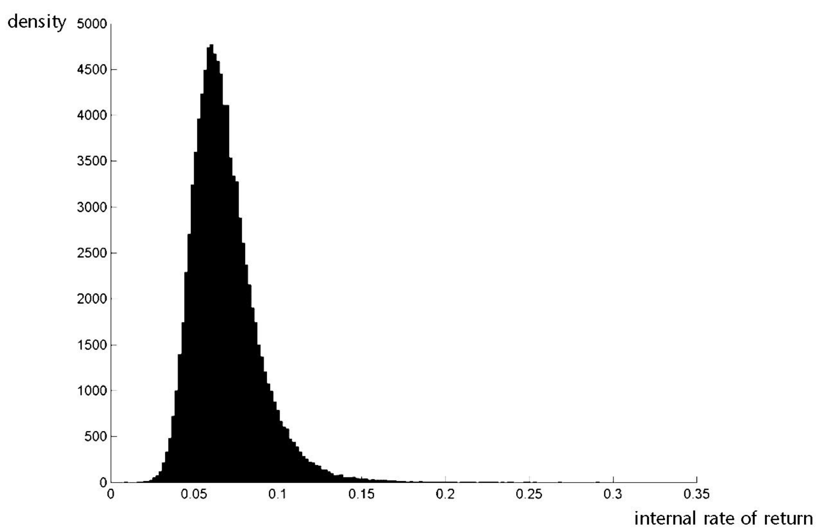


Figure 6 The distribution of internal rates of return. Independent errors in schooling and no-schooling ln earnings, with means 0 and standard deviations 0.45; returns to years of schooling 0.065; experience profile, linear term 0.05, quadratic term -0.001 in both careers.

Source: Hartog, Van Ophem and Bajdechi, 2004.

RESPONSE TO RISK IN EDUCATIONAL CHOICES

Intuitively, one would think that risk plays an important role in decisions on extended schooling. As noted above there are many uncertainties facing an individual and one cannot imagine that individuals will brush them aside and only consider expected value of the relevant variables. Yet, risk is not a dominant theme in the economic literature on schooling. There are two basic models, each with very modest follow-up. Levhari and Weiss (1974) presented the first model. They divide future life in two periods, schooling and working. The pay-off to choices made in the first period, during working life, is uncertain. Individuals draw up a plan for their first period decision, and stick to that. Under conditions, the model predicts that increasing risk (increasing variance in the pay-off to school time) will reduce time spent in school. The second approach starts with Williams (1979) and is based on continuous decision making as information unfolds (stochastic dynamic programming). Individuals are not assumed to take all their decisions up front and stick to them, but continuously consider whether to remain in school or to quit and start working. Williams' model is very rich and detailed. It also predicts investment in education to fall if risk in the returns increases, provided some conditions on parameter values apply. Hogan and Walker (2001) apply a similar approach, though much simpler than Williams, and conclude that increasing risk increases rather than decreases investment in education. They measure risk as the variance of the wage that individuals can earn straight upon leaving school. As this variance increases, it becomes more attractive to stay in school longer, and to wait for an unusually large wage offer (once the individual has started work, the wage remains constant; the unusually high wage would apply for the rest of working life).

Hartog and Diaz Serrano (2002) construct a basic model similar in spirit to Levhari and Weiss (1974). After compulsory education, students decide on their desired length of schooling, by equating marginal cost and marginal benefit, as in Figure 2, now with risky rather than certain marginal benefit. Risk averse individuals (individuals who only accept risk if they can expect a premium in the returns) will opt for shorter education if risk in the return increases. The intensity of the reaction to risk will depend on the magnitude of risk aversion (the premium individuals require for accepting a given risk). We estimate this model on Spanish data. Risk is measured as the residual variance of income in the individual's province of residence. Or, more precisely, the variance of earnings for individuals with university education relative to those with only secondary education.

We then estimate the inclination to go to university in response to this relative risk. Interestingly, we have a measure of risk aversion, as the share of household income spent on lottery tickets (lotteries are a pervasive fact of life in Spain). We reckon that less risk averse households spend more money on lotteries. The results then support the basic prediction of the model. In provinces where investment in a university education is more risky (with a university education, graduates move into a more dispersed earnings distribution), individuals are less inclined to go to university. The reaction to risk is mitigated by the extent of risk aversion, however: less risk averse individuals are less affected by the riskiness of the investment. We estimate that an average individual will require 2% higher expected income for a 10% increase in risk (relative variance in income).

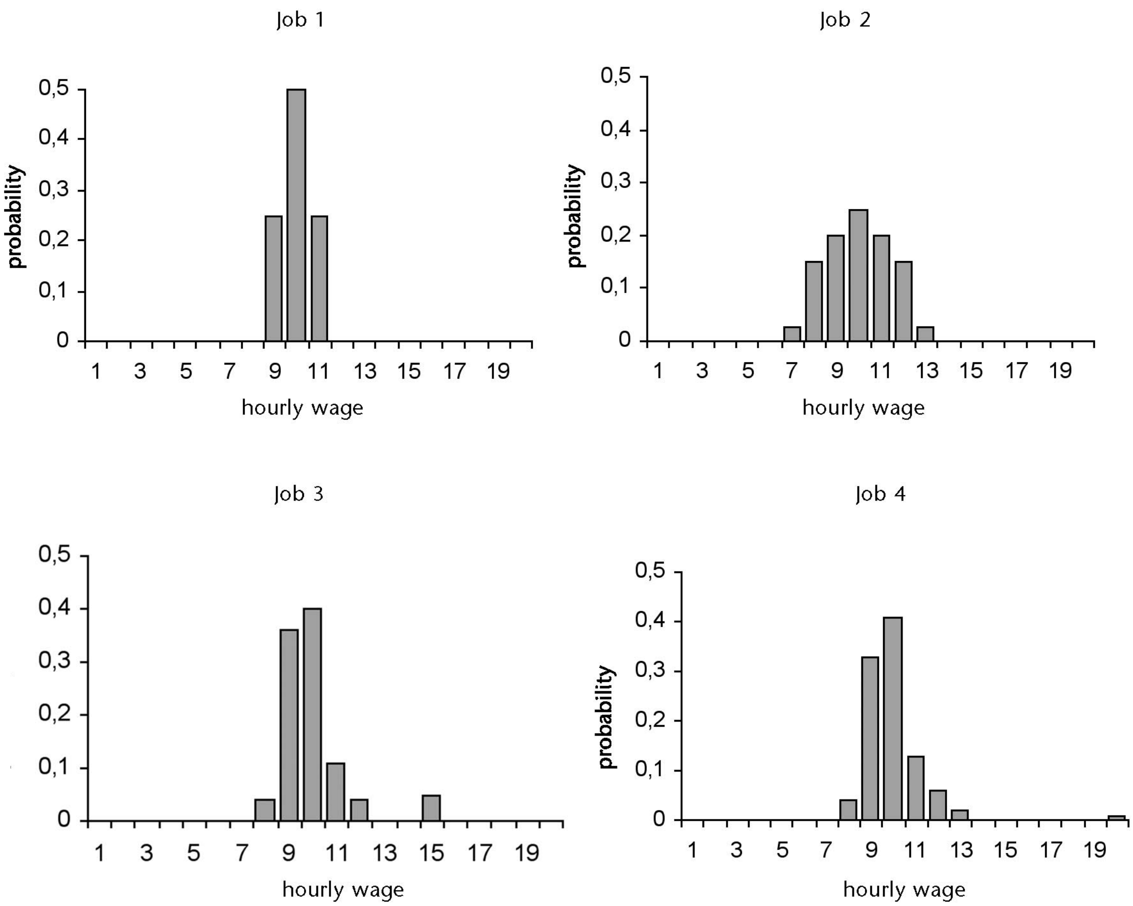
RISK COMPENSATION IN THE LABOUR MARKET?

> 'In a perfectly fair lottery, those who draw the prizes ought to gain all that's lost by those who draw the blanks. In a profession where twenty fail for one that succeeds, that one ought to gain all that should have been gained by the unsuccessful twenty'.

That is how Adam Smith continues his discussion of the risk involved in choosing a profession. Simple arithmetic shows he is right: if expected income in a risky profession should be equal to income in a profession without risk, expected losses and expected gains (relative to the sure alternative) should be equal.

Does the market provide any compensation? To analyse this question, we have adopted the following approach. To control for length of education, experience and, when relevant, gender and region, we regress individual earnings on these variables. We then consider the residual from the regression for all individuals in a given education-occupation category (e.g. university education in economics, laboratory assistants with a chemical training at a polytechnic, etc). The residual is the part of income left unexplained by the variables in the regression. For the residuals of all individuals in the given cell we calculate the variance and the skewness. The variance is the measure of risk within that education-occupation cell. Individuals generally don't like risk and want to be compensated for it. In education-occupation cells with higher risk, on average individuals should earn more, otherwise supply would not be forthcoming. If we include the variance in the regression we should find a positive coefficient. Acknowledging skewness allows an interesting refinement of the analysis. Skewness is a measure of asymmetry in a distribution. Earnings distributions generally are positively skewed: the upper tail is fatter than the lower tail. Most individuals appreciate this. The intuition is that, for a given mean and variance, individuals prefer a distribution that is skewed to the right, as they appreciate the small probability of a substantial gain. The intuition is borne out in a simple classroom experiment described in Hartog and Vijverberg (2004), used when teaching statistics to undergraduates. The class is confronted with a choice among four jobs, each with an uncertain wage as shown by the four distributions in Figure 7. Not surprisingly, students tend to prefer job 1 to job 2, as it has smaller standard deviation at equal mean: they take no risk without compensation. Interestingly, they also tend to prefer job 4 to job 3 (and frequently also job 3 to job 2), as they appreciate the small probability of substantial gain. In the consumption-savings literature, there is strong support for the assumption of skewness affection, or prudence as it is called there (Gollier, 2001, p. 238).

All the empirical work we have done so far indeed finds a positive effect of risk (variance) and a negative effect of skewness on earnings. Our initial analyses (Hartog, Plug, Serrano and Vieira, 2003; Diaz Serrano and Hartog, 2004; Hartog and Vijverberg, 2004) were based on education-occupation groupings, simply because these data were immediately available. However, occupation is a less than satisfactory basis. If, in a risky occupation, individuals turn out to be unlucky, they may move to another occupation. That would make observations in that occupation quite selective. The problem is not relevant for a grouping by education: you cannot undo an education. Whether we use occupation or education, we always obtain coefficients with predicted sign, at high levels of statistical significance. So far, results have been found for the USA, Germany, Spain, Portugal, Denmark and in several datasets for The Netherlands. For Denmark we have longitudinal data (Diaz Serrano, Hartog and Skyt Nielsen, 2004). This allows us to use alternative measures of risk. Rather than using the residuals from an annual earnings regression, we can use measures based on individuals' actual movement through the income distribution during a career. With such alternative measures, we get essentially the same results. Research in progress uses measures of ability, such as test scores (Hartog, Bajdechi and Van Ophem, 2004a) and school grades: controlling for measured ability purges the residual of individual heterogeneity, as individuals will know their test scores and school grades. Using residuals after these controls have been included still strongly supports the predictions.



	Job 1	Job 2	Job 3	Job 4
mean	10.00	10.00	10.00	10.00
stdev	0.71	1.43	1.43	1.43
skewness	0.00	0.00	2.06	3.60

Figure 7 Choosing among Risky Alternatives

Table 4 presents results from the empirical analyses so far. For ease of comparison, we have given the effect on mean income if risk or skewness would be entirely eliminated: a reduction from actual mean value in the sample to zero. There is a fair amount of dispersion in the estimates, but still the distributions are reasonably concentrated. The impact of risk is larger than the impact of skewness in 20 out of the 25 estimates. The modal value is 11.4% change in income for risk elimination and 3.2% for skewness elimination.

Are students 'under recompensed'?

Adam Smith judged that the financial risk of professions is 'under-recompensed'. His assessment relates to counsellors at law, as he observed them in his 18th century environment:

> 'The lottery of the law, therefore, is very far from being a perfectly fair lottery; and that, as well as many other liberal and honourable professions, are, in point of pecuniary gain, evidently under-recompensed' (Smith, 1776 (1976), 208).

It would be most interesting if we could properly assess Adam Smith's evaluation, in our present environment. Is there sufficient compensation for the risk associated with engaging in a lengthy education? Do markets function properly in that respect? The question is hard to answer, for practical and methodological reasons. The methodological complication is in the heterogeneity of individuals. Individuals may very well differ in the risks in the various educations and occupations. Someone with a talent for music may have a smaller risk from going to conservatory than someone who can never distinguish between Mantovani and Mozart. But such effects are hard to measure empirically. Individuals will also differ in their risk attitudes. Not everyone will require the same compensation for a given risk. Some may like a touch of unpredictability and variation in their earnings (and may, for example, decide to set up their own business). Some may try to evade all risk as much as possible (and seek the predictability and security of a government job). Thus, it might very well be that some risky occupations generate little compensation for this risk, simply because those working in that occupation are not bothered by risk. A proper assessment of risk compensation should be based on proper knowledge of risk attitudes, and the variation therein among individuals.

Measurement of individual risk attitudes is a treacherous issue in economics. The dominant view is that risk attitudes (and other parameters reflecting taste and preference) should be retrieved from 'revealed prefe-

Table 4 Percentage change in income[a] if risk and skewness are reduced from sample mean values to zero.

	Risk (R)	Skewness (K)
USA, education/occupation[b]		
men	-10.6	+12.5
women	0.0	+ 8.7
USA, occupation[d]		
men	-23.1	+ 3.5
women	-15.0	+ 1.8
Spain, occupation[c]		
full sample	- 2.0	+ 1.0
men	- 2.5	+ 1.6
women	- 3.6	+10.1
public sector	- 8.6	+ 9.0
private sector	- 1.8	+ 1.2
Spain, occupation[d]		
men	-29.0	+ 1.6
women	- 9.5	+ 2.0
West Germany, occupation[d]		
men	- 11.4	+ 2.0
women	-24.6	+ 5.3
East Germany, occupation[d]		
men	-12.0	+ 1.1
women	- 8.4	+ 1.5
Portugal, 1992, occupation[d]		
men	-36.6	+16.6
women	-76.2	+ 3.2
Netherlands, occupation[d]		
men	- 17.6	+ 4.6
women	- 15.3	+ 6.2
Netherlands, education[e]		
men	-35.6	+ 8.9
women	- 2.9	+ 1.5
immigrants	-25.0	+ 6.5
natives	-22.7	+ 6.7
Denmark, education[f], men		
permanent shocks	- 1.0	+ 0.0
transitory shocks	-10.7	+ 0.3

a more precisely: change in Ln income
b Hartog and Vijverberg (2002), NBER-CPS, Table 4
c Diaz Serrano (2000), Table 7.3, p. 144
d Hartog, Plug, Diaz Serrano and Vieira (2003), Table 2
e Hartog and Webbink (2004), Table 1 and means given in the text
f Diaz Serrano, Hartog and Skyt Nielsen (2004), Table 5

rence': tastes are reflected in the actual choices that people have made. With econometric techniques we should uncover the structure of preferences. As an extreme example: if individuals can choose between a safe and a dangerous job, and they show no preference for one over the other, and wages are equal in both jobs, the safety risk is apparently immaterial to them. If the market would push up wages in the dangerous job, we could recover the apparently required compensation, and hence the extent of aversion to job hazards. Much work has been done on risk attitudes in financial decisions: saving and asset portfolio management. The literature has mostly generated puzzles, rather than reliable and robust information on risk attitudes. For example, the premium observed in the stock market for equity relative to safe investments is much higher than the required premium that can be deduced from structural econometric ('revealed preference') models, which would suggest that stock market risk is 'over-recompensed'.

We are a long way from a convincing answer to the question we have posed here. But we can still try to get some crude feel for the magnitudes involved by drawing on results that are available. In Table 4 above, we presented estimated effects of eliminating risk altogether. Dividing these estimates by 10 indicates by how much expected income would increase for an increase in risk by 10%. Roughly, these estimates suggest an increase in expected income by some 1 to 4% for an increase in risk by 10%, with the modal value at 1.14%. Our Spanish estimate suggested that participation in university education would remain constant if a 10% increase in risk would be associated with a 2% increase in expected income. That would suggest that, perhaps, labour markets provide the required compensation in some countries and not in other countries. But his is obviously only a very crude impression.

One might think that lower participation in extended education from lower social backgrounds has some roots in higher risk aversion. After all, with higher incomes it is easier to absorb some risk. Again, these are not issues on which the literature provides much guidance. In Hartog, Ferrer-I-Carbonell and Jonker (2002) we estimated risk attitudes directly, by asking individuals what they would be willing to pay for a specified lottery ticket. The effect of parental background on required compensation for risk appeared modest: if the parents had a low education rather than a high education, required risk compensation would not increase by more than 5%. However, this is a trans-generational effect. The data also indicate that a 10% lower income increases required risk compensation by 13%. If this estimate would be representative, the effect of parental risk attitudes on educational choices of children may be substantial. But nota bene:

this is just first sketchy evidence on parameters that we know very little about.

A BRIEF CONCLUSION

Empirical results indicate that the risk involved in choosing an education is by no means negligible. We also have found evidence that the labour market generates compensation, in the form of higher wages for higher risk, and lower wages for more skewness in the earnings distribution. It might be that in some countries, the market compensation is indeed commensurate with what individuals demand.

Much work remains to be done. The most pressing issue is to allow for heterogeneity among individuals and selective allocation in the labour market. Indeed, risky education might be undertaken more easily by individuals who are less risk averse. But in such issues, our evidence is sketchy, and inferences are speculative. There is an interesting challenge for very relevant research.

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APPENDIX. THE EQUILIBRIUM WAGE STRUCTURE

With constant annual wage rate W_0, discount rate r and age of retirement T, the present value of going to work rightaway is

$$V_o = \int_o^T W_o e^{-rt}\,dt = \frac{W_o}{r}\left(1-e^{-rT}\right)$$

With post-school age W_S and annual schooling cost K (tuition, books, etc), the present value of schooling for S years and work thereafter will be

$$\begin{aligned} V_s &= -\int_o^s K e^{-rt}\,dt + \int_s^T W_s e^{-rt}\,dt \\ &= -\frac{K}{r}\left(1-e^{-rs}\right) + \frac{W_s}{r}\left(e^{-rs}-e^{-rT}\right) \end{aligned}$$

Equilibrium, with individuals indifferent between schooling and non-schooling, obtains if

$$V_o = V_s$$

which can be solved for the equilibrium schooled wage:

$$W_s = W_o \frac{1-e^{-rT}}{e^{-rs}-e^{-rT}} + K\frac{1-e^{-rs}}{e^{-rs}-e^{-rT}}$$

If we simplify, by assuming K=0 and letting $T \rightarrow \infty$, we get

$$W_s = W_o e^{rs}$$

which can be written as:

$$LnWs = LnWo + rs$$

Hence, log wages are linear in years of schooling s, with slope equal to the discount rate r.