On Risk in Educational Choice: Brief Overview and Research Note

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1 Empirical evidence on risk in returns to education

Choosing an education abounds in uncertainties. When considering to enroll in any type of schooling the individual faces at least three major insecurities. Firstly and secondly, with regards to the education under consideration per se, the individual cannot assess whether he/she will be able to complete the education (i.e. he has a drop-out risk) and respectively, he/she cannot predict what will his relative position in the post-education earnings distribution be (i.e. he has a poor performance risk in the labour market). Thirdly, with regards to the value of the education or of an alternative occupation, the individual cannot know for sure whether this value will not shift over time as a response to market factors such as technological changes, relative supply, etc. (i.e. he has a market risk). These issues considerably complicate the life of the subject making the choice while at the same time, which is much more important to our purpose, they set hurdles before the researcher who wants to investigate the process of the investment in education. The very first difficulty arising is simply estimating the risk in the returns to education; measuring "risk" is not straightforward and though considerable progress has been achieved in this realm, there is much to be done still. In what follows we will attempt to give a short overview of existing empirical evidence on the risk in the returns to education.

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Not much is empirically known about the risk associated with investment in human capital. This is proxied by the insufficient knowledge about the dispersion in returns to education to start with, despite the fact that heterogeneity within individuals and consequently within their returns has been emphasized in economic research for several decades now (one of the earliest contributions being Willis and Rosen (1979)). We begin by highlighting the difference between the ex-post variability of returns and ex-ante risk in returns to education. The ex-post rate of return quantifies how much the individual gained from his education in comparison with his best alternative option; since this non-selected alternative cannot be observed, self-selection issues arise. Thus, the ex-post return is determined for subjects who completed some level of education, for particular exits from the schooling-system; the ex-ante return is measurable by considering the returns of those who once entered some form of education. Ex-ante returns include as a consequence the drop-out risk in their computation, which is obviously overlooked in the ex-post returns approach. In principle, having data on individuals who started some type of schooling, one should be able to calculate ex ante returns for every next step, such as every next year spent in the schooling system. In practice there is nonetheless a clear difference between estimating ex-post versus estimating ex-ante returns, since the latter poses much more snags. Namely, the variance in the ex-post rate of return to schooling can be characterized considering earnings differentials over the lifecycle and relating this to the amount invested. There are several paths one could follow for this, and the existing literature is illustrative in this sense; we will see below some of the evidence. On the other hand assessing ex ante risk of investment in schooling requires equating lifetime earnings when under the no-schooling alternative with expected lifetime earnings from all potential exits once the individual has entered an education–or this information is most of the time impossible to obtain. Next, an additional difficulty comes to disturb the researcher and that is concerned with how much the individual knows about his own ability, future effort exercised and so on. This apriori individual knowledge assumption decides on the correlation between individual heterogeneity and his risk taking. It should not come as a surprise therefore that there are hardly any studies dealing with direct estimates of ex-ante risk in returns to education[1]. But let us go over some of the empirical findings

[1] Altonji (1993) seems to be one of the very few, if not the only one, who tries to estimate ex ante returns directly. He focuses on continuing the college after having completed highschool and estimates ex ante returns by probit equations for education level; the probit is estimated for a given entire cohort of high school graduates and the predicted probabilities are combined with the coefficients of the schooling dummies

in the context of risky investment in schooling.

As asserted above, we will concentrate on skimming through the relatively abundant literature dealing with ex-post variation in the returns to education. One flow in this literature deals with investigating earnings distributions by education attained, the attention being on whether different schooling implies different variances in the individual earnings distributions. These distributions might give, if we maintain the assumption that the subjects cannot condition them on covariates they know when entering the education, a rudimentary account of differences in risk across individuals, with higher variances in the earnings indicating higher risk (see also the brief comment in the previous paragraph on the correlation between individual heterogeneity and risk). Other controls like age and experience have also been used in the literature in order to stress different risk profiles over the career. It seems (see brief survey in Hartog, Ophem and Raita (2003)), that the results are disappointing in the sense that there is no agreement whatsoever between them, there is no uniform pattern, no convergence. And this happens irrelevant whether the distribution of earnings itself, or residuals from an earnings function adjusted for appropriate controls, are considered. In the perhaps earliest research in this context, Becker's (1964) "Human Capital", more schooling is found to increase the dispersion in earnings; Weiss(1972) finds that variation in earnings decreases with education for a cross-sectional sample of US scientists[2], while it is at the same time U-shaped with the experience; Hartog, Oosterbeek and Teulings (1993) use several cross-sections of data on the Netherlands and find the earnings variation to increase with education in all these cross-sections, while experience is found to have null effects on the earnings variation; Belzil and Hansen (2002) use a sample from the NLSY panel data study and estimate an original dynamic programming framework of schooling decisions, finding that both earning and employment rate variations decrease significantly with schooling attainments; to add to the controversy, a very recent study by Chen (2003), using yet another NLSY longitudinal sample for US college and high-school attendees and an interesting multi-stage identification procedure, claims to have improved the measure of wage volatility and to have accounted for selection at the lower end of the distribution, and obtains that wage volatility (the permanent component of the wage volatility) increases significantly after attending

in a wage equation.

[2]Hause (1974) criticises Weiss (1972) on grounds that some of his major results are highly sensitive to the utility form chosen. Nonetheless the positive correlation between the ex-post dispersion in the earnings and the schooling seems to be robust to the critique (this specific result is not aimed at by Hause's comment)

a four-year college. All in all, the empirical evidence on earning distributions by education is divided amongst all possibilities: earnings variance may apparently increase, decrease or even have no relation at all with education. Inter alia this result suggests that the education systems in different countries have different functions in their ex-post relation with the labour market; of course, should we maintain the assumptions of the apriori no-knowledgeable individual (see start of this paragraph), these results also suggest that the risk in schooling investment differs across countries. A generic comment to be made with regards to this type of research in the context of the risky investment in human capital is that it might well be that this crude income dispersion does not accurately measure risk, hence some caution might be wise in here.

Another stream of research within the ex-post returns to schooling consists in looking at the variation of the Mincer coefficients in the standard case across time and place or across individuals. If we think about the variability of the Mincer coefficients over time and place, one rationale for doing this type of investigation is the fact that repeated Mincerian estimates over time, in a given place, can provide some indication of the risk characterizing the shift in the market value of schooling, as a consequence of several possible factors (the market risk that we were mentioning in the beginning of this section). Some examples of studies in this context are briefly discussed in the following. Hartog, Oosterbeek and Teulings (1993) have found, using cross-sectional data over several years from the Netherlands, that the return from human capital has fallen dramatically from 1962 to 1985, and afterwards it has risen slightly before 1989[3]; Trostel, Walker and Woolley (2002) use instrumental variables estimation on comparable microdata (pooled cross-section surveys over 11 years) from 28 countries to find considerable variation in the rates of return across countries. At the same time they find no evidence of increase in the rates of return to education from 1985 to 1995. Finally, one attention-grabbing paper in this sector is Ashenfelter, Harmon and Oosterbeek (1999); they perform a meta-analysis of 96 previous estimates of the rate of return on educational investments, measuring how these estimates very by country, time and estimation method; the general upshot appears to be that there is no much controversy on the idea that schooling adds considerably to the earnings of the individuals, but there is however a debate around the endogeneity of the schooling variable, implying that the observed correlation between schooling and earnings could be merely hiding a correlation between un-

[3]This comes in contradiction with the evolution of the rates of return to human capital in studies using data from other countries such as US, UK or Australia, where the return to human capital constantly increased during the 80's

observed factors such as ability, and earnings. But of course this is the old story of the schooling endogeneity and all the spice that comes along with it. What is important to take into consideration from this study is that there are relatively small differences among the estimates produced with different estimation methods. It also appears that within the countries the variation in the rates of return to schooling is relatively stable over several decades and that the Netherlands might well have constituted the only exception. Some information in this sense is also available from research on differences in the rates of return to education between individuals. The number of studies herein is also much more limited: Harmon, Hogan and Walker (2003), for example, use a random coefficient technique to estimate a heteroskedastic model for the returns to education on a sample of UK data; they find considerably large dispersions around the mean and even individuals with negative returns. The problem with this study is of course the fact that while it emphasizes the variance in the earnings differences that are generated by education differences, it does ignore other potential parameters that might determine the rate of return, as hinted to in the previous discussions.

A different approach than the ones underlined above, but related to Mincerian coefficients varying over time and space, is to look for wage compensation for the risky investment in schooling. This literature is rather sporadic, consisting mainly of very recent studies, with few exceptions[4]. The background idea is that, under expected utility theory, foreseeable risk should determine the increase of the later compensation for work. There is a stream of previous empirical literature that uses measures of earnings dispersion in the Mincerian context to test for risk compensation, such as McGoldrick (1995) or McGoldrick and Robst (1996); therein risk is measured from the variance of the residuals in a cross-sectional earnings function, with several controls such as education and experience, with residuals collected by occupation or industry. While taking over the background setting, the new line of research, also introduced the skewness dimension in the distribution of the compensation paid; namely, people do not only worry only about risk, but they also appreciate a small chance of a substantial gain, exhibiting thus not only risk aversion but also skewness affection[5]. Hartog and Vijverberg (2002) develop various measures of risk and skewness and test these

[4]Indeed, one of the earliest articles to consider the variance of earnings by schooling levels and correct the estimated rates of return for different degrees of risk aversion was Weiss (1972).

[5]The "skewness affection" concept has been applied previously in other contexts such as betting in horce races and other sorts of gambling (Golec and Tamerkin (1998) on horce race betting, Garrett and Sobel (1999) on US state lotteries).

hypotheses by occupational-educational classification of worker, using data on 5 countries and a 2-stage estimation procedure. In a nutshell the model materializes in individuals facing several schooling options and only undertaking them when they are sufficiently compensated for it. The authors find indeed that wages rise with occupational earnings variance and decrease with skewness. This would indicate that there is wage compensation for higher risk taken when investing in education. One dilemma rests nevertheless in the way risk faced by individuals is computed; Hartog and Vijverberg use contemporaneous measures of earnings variability and skewness for the risk and respectively skewness at the moment when individuals make their education choice. Or this only works if we make the assumption that variance and skewness remain stable over time. There is hardly any complete solution to this dilemma however and trial-and-error seems to be the most feasible approach for the time being. In any case, the advantage of this research is that it opens routes for further studies where perhaps more direct measures of risk attitudes could be employed. Studies of a similar pattern are Hartog, Plug, Diaz-Serrano and Vieira (2003) and Diaz-Serrano, Hartog and Nielsen (2003). The first of the two replicates data for the US to test for the effect of earnings variation on individual earnings on 4 European Union countries and finds, in conformity with the theory of wage compensation for risk averse workers, that individual wages rise with the variance and decrease with the skewness of earnings in the individual's occupation. The second uses 17 waves of longitudinal data from Denmark and decomposes shocks in earnings in a permanent and a transitory component, testing the role of risk associated with both these components. The novelty comes in the fact that the data allows measuring the risk and skewness of the earnings associated with education level only, this having a comparative advantage over Hartog and Vijverberg (2002) mentioned above, who used education-occupation levels. With observations by schooling type the selection mobility problem can be avoided and the problem of not generating sufficient observations on risk is diminished. The outcome is that both the permanent and the transitory components of the earnings risk are associated with compensating wage differentials, with transitory shocks in earnings being more relevant for compensating wage differentials than permanent shocks. As a summary of this last discussed empirical approach, although the literature on the subjects is very scarce, it seems that the empirical upshots are certainly consistent. This is therefore one approach worth to be further pursued and extended since it does promise a lot.

Finally, a research related to the one discussed above, so still dealing with the idea of compensation in wages for more risk in the investment in

human capital, but quite unique and not followed or preceded by other studies as far as I can tell, is the study by Shaw (1996). She develops a model of joint investment in financial wealth and human wealth to show that human capital investment is an inverse function of the degree of relative risk aversion. The author makes use of the information contained in risky financial decisions to make inferences about individual heterogeneity in risk aversion. The theoretical framework suggests human capital investment and income growth to decline with risk aversion and with the variance of returns to the investment. The implementation of the model is very elegant and it makes use of data from the Survey of Consumer Finances (SCF), covering 1983-1986, for the estimation part. As empirical outcomes, Shaw (1996) obtains that risk averse workers have lower returns to education, to general experience and to tenure; they also appear to be less likely to undertake risky post-school investment; next, assuming the variance of returns to investing rising with education, income growth for risk takers rises with the variance, as predicted theoretically. Thus, in other words, wage growth is positively correlated with preferences for risk taking, and individuals with more education are more likely to be more risk takers, hence risk taking is shown to explain quite a bit from the returns to education. Some worries about endogeneity in the returns of education are there, but the study is in itself a very good one and worth extending. Certainly re-estimating Shaw's model for a different sample (although the features of the SCF study are quite unique, so an alternative would be hard to find) is a must and should be done with the first occasion.

2 Comparing models of risk in educational choices

The effect of risk on human capital investment decisions has always been a hot and challenging topic within the research dealing with earnings uncertainty in general. This literature basically starts with the seminal paper by Levhari and Weiss (1974), which is the adopted standard model for human capital decisions under uncertainty. More recently other models, mostly based on stochastic dynamic programming approaches, have been developed and also achieved sometimes opposite conclusions than the original Levhari and Weiss (1974) framework, as we will see below in this section. The main ones that we will comparatively investigate in this short summary are Hogan and Walker (2001), Belzil and Hansen (2002) and Hartog and Diaz-Serrano (2002). In the remainder of this section we will take a brief look at each of these models, underlie their similarities and emphasize their differences.

Right from the beginning we should observe that all these four models deal with effects of changes in the post-education earnings, although

they differ in what they label "risk". This conceptual difference together with the structural distinctions across the models explain basically the different results these models convey. Levhari and Weiss (1974) introduce a two-period model composed of a schooling and respectively a working period. Time division between schooling and working is allocated in the first period, while working time is set in the second period. There is uncertainty in the returns to schooling. We will avoid here going through the formal part of the model entirely, but rather emphasize the outcome: Levhari and Weiss clearly predict that increasing risk will reduce investment in human capital if good states of the world generate higher marginal returns to schooling, i.e. if for instance higher ability individuals have higher rates of return[6]. The empirical evidence on this model is mixed. Eaton and Rosen (1980) confirmed empirically Levhari and Weiss's theoretical findings, while Kodde (1985) observed empirically the opposite effect. Levhari and Weiss's model is of course a stepstone for all research dealing with human capital investment under uncertainty; it is very clear assumption-wise and its statistical background has been backed up by several empirical studies; besides its risk-attitudes upshots, one of the major contributions to the literature is revealed importance of the correlations between the average and marginal returns to schooling and between the human and the non-human capital, previously stressed by Becker. One weakness of the model is that it does not allow for investment in human capital over time, lacking any sort of inter-temporal setting, so that reality is better approximated; the one-shot model is somewhat far-fetched in terms of assumptions, although it is to be expected that the behavioral pattern won't change too much over subsequent periods. To our knowledge an inter-temporal adaptation of Levhari and Weiss's (1974) initial model has not been done yet.

Using as point of departure the early model of stochastic dynamic programming applied to education decisions of Williams (1979), Hogan and Walker (2001) construct a similar type of framework where being in school has a utility value and the wage to be realized when leaving school follows a Brownian motion. Williams (1979) adapted the optimal portfolio choice model of Merton (1971) to allow for investment in human capital. To this extent, human capital has been defined as the market value of individual's current stock of skills and it evolved in a stochastic fashion over time leaving the individual with the choice of al-

[6]On empirical grounds this is most of the time satisfied of course, namely the more "endowed" individuals usually have higher rates of returns. If this assumption is sound, then the conclusion of the study is that, as put forward above, a maximizing individual will reduce his investment in human capital under conditions of uncertainty

locating time to human capital accumulation or to work or leisure. The ideological distinction between Williams's model and Hogan and Walker 's(2001) is that the former treats education continuously and taking place at the same time as work, which is hardly a realistic assumption, except situations when all education is confined to on-the-job training programs. In practice education usually takes place before work and the whole stochastic problem can be seen more like an optimal stopping problem than a portfolio choice scenario. This is the reason for Hogan and Walker to model the schooling choice as subjects staying in education full time until they find it optimal to leave education and stop, with no option of return. Education is thus seen as an irreversible investment; the techniques to analyze this problematic have been laid down in Dixit (1989) or Dixit and Pyndick (1993)**?**, among others. To sum up, the way Hogan and Walker (2001) conceive their model is that the individual in school has an option to leave that can be exercised any time and thereafter to take up work at a wage stochastically related to the time spent in school; of course once the "tree is cut" (optimal stopping problems are also referred to as "tree-cutting problems"), the individual cannot return to school any longer. Without entering the details of the model, in an elegant way, using Bellman equations and financial option tools such as Ito's lemma, Hogan and Walker (2001) attain the result that increasing risk will increase the schooling period, result which does not seem to be dependent on the risk preferences of agents, as it also holds for risk-neutral ones. This outcome stems from treating education as an option and it is indeed a counter-intuitive result, since one would expect that higher risk would lead to less investment in human capital, which is obtained in the standard type of human capital investment under risk framework of Levhari and Weiss(1974) and their followers. There is however much to be improved in this analysis. Firstly, the assumption of leaving once and for all the education process is not realistic; people do continue their education particularly through specific training, but we can also talk about temporary periods of stopping and taking up work, and returning to education later; even more of a complication could be stopping education, but not working, which introduces a third alternative: non-employment (or unemployment, but that would be even more difficult since we have to separate out those out of the labour market from the ones seeking work). Extension with a possibility of undertaking on the job training or considering also non-employment as choice as an alternative to education, might be thus an interesting endeavour. Secondly, there has been already some critique in the schooling treated as characterized only by length, albeit the subjects have not completed the degree program started. A challenging thing to do would be to

consider the schooling in steps, since intuition tells that in terms if returns, completed degrees yield more than stopping in the middle of the course. Finally, of course, this model ought to be tested empirically in an appropriate data set.

Belzil and Hansen (2002) use a similar type of model as the above in terms of methodological setting, a stochastic dynamic programming framework. The theoretical insight of the model is however different than the one in Hogan and Walker (2001) and proceeds as follows: individuals are initially endowed with family human capital, innate ability and preference parameters. Given their endowments, young individuals decide sequentially whether it is optimal to enter the labour market or to continue accumulating human capital in school. The individual in school is supported by parental transfers or by school support, the net income in school being assumed to be non-stochastic. Individuals may interrupt education for exogenous reasons such as illness, injury, travel or academic failure—what is an important hypothesis here is that the human capital remains constant over the interruption period. Once the individual decides to enter the labour market he does not receive parental support or school support any longer, but gets a wage rate and an employment rate, which are perfect substitutes. Each subject maximizes his expected discounted lifetime utility by choosing the optimal time to interrupt schooling and to enter the labour market. We note that Belzil and Hansen (2002) address some of the potential issues overlooked in Hogan and Walker (2001), albeit they do this in a different setting, such as temporary stopping education or modelling wage and employment rates as substitutes in the model. Belzil and Hansen also estimate empirically their model on a NLSY sample covering 1979-1990; they conclude, in the same spirit as Hogan and Walker, that an increased variance of labour earnings, so an increase in risk, increases schooling lengths. This is accounted for in their model by the fact that increased risk in the labour market makes schooling more attractive since that comes with receiving riskless parental income support. We have however some objections to the plausibility of this model, since parental support in a pecuniary understanding is often non-existent or marginal, the subject in school working part-time for his extra money; while the support in non-pecuniary matters (accommodation, meals, etc.) is not contingent on being in school but on living with the parents. The model is thus a very interesting perspective on the problem, but to our opinion it cannot bring more than didactical insight in the matter. The parts worth noting and possibly taking over in a more realistic model are the assumptions concerning interruptions from school (but then depreciating human capital in a non-active period should be accounted for), and

the elegant modelling of the wage rate and employment rate.

One final model we will discuss in this section is the one by Hartog and Diaz-Serrano (2002). This model also analyzes the effect of the non-deterministic post-school earnings on the optimal education length; however the authors claim to have used a much more simple and elegant methodology to this aim, compared with the dynamic stochastic programming models discussed previously. In terms of upshots, their theoretical model stays in the line of Levhari and Weiss (1974) for the risk-averse individuals, but agrees with the results in Hogan and Walker (2001) and Belzil and Hansen (2002) when the risk-loving individuals are in the discussion. Namely, it is found that increasing risk in future income would induce a negative effect on the individual's educational length for risk-averse individuals, but a positive effect for the risk-lovers. In terms of structure of the model, the individual faces some potential earnings, contingent on the realized schooling length, in a very simple multiplicative stochastic specification, in a spirit similar to Levhari and Weiss's (1974) model with two periods, with a wage unknown when deciding on schooling, but with a single lifetime realization (so one wage for the whole post-schooling period). The derivation is indeed straightforward and the upshot is decided in function of the increase or decrease in the risk gradient (for a quick image of how the model works see pages 4-7 in Hartog and Diaz-Serrano (2002)). As stated above, the authors conclude that an increase in the risk gradient reduces the optimal schooling length for risk averters and it increases it for risk lovers. These predictions are checked empirically in the paper using a Spanish cross-section sample from a nationally representative survey. Hartog and Diaz-Serrano investigate the decision to continue education at the university level or not after completing secondary education and their estimates confirm the conclusions on the risk attitudes arising from the theoretical framework. As a general impression, this model is extremely attractive given its simplicity, however it achieves this malleable form at the expense of the somewhat rigid assumption that the individuals must make initially a single decision on their education length; in this sense the stochastic dynamic models analyzed above are superior (the individual might modify at any point his/her decision of continuing schooling); albeit this assumption might not change the general results, a search on how sensitive the outcome actually is to this specification, is necessary. Of course, a confirmation of the results achieved for Spain, using data from other countries, would also help in disseminating the assumptions of this model as feasible ones. All in all, there is ground for lots of research further on this frequency.

As we have seen from this short comparative analysis, it appears that

the literature on the effect of uncertain returns to education on the decision to invest does not converge. We have discussed some studies where increased risk may increase (Hogan and Walker (2001) and Belzil and Hansen (2002)), decrease (Levhari and Weiss (1974)) or both increase and decrease (Hartog and Diaz-Serrano (2002)) the investment in education . There is consequently much to be done still; if we are to choose a promising and motivating topic, extending the dynamic programming approach of Hogan and Walker (2001) and empirically estimating this model, as discussed in the corresponding paragraph above, could be a first idea to embark on. At the same time, the model in Hartog and Diaz-Serrano could be made less rigid (see paragraph above) and empirically estimated on other datasets. This seems to sort of fill in any research agenda for quite a while.

3 Research proposals in the context of risky investment in schooling

There would be many things to implement since, as we have seen from the above discussions, the context of risk in the investment in human capital under uncertain conditions is pretty much a virgin field yet. While some thoughts have been put forward hereinabove, while summarizing the current status-quo, we will put discuss in what follows more in detail (time and space do not permit however a full research proposal treatment in here) just a few very interesting ideas that might be pursued in the near future, ideas on which we do in fact intend to work with the first opportunity.

To begin, we will dwell on some estimation technicalities which however, often ignored, might significantly contribute to shed a clear light on the clear empirical standing of the research concerning investment in schooling under uncertainty It is a fact that, au contraire to the basic human capital model, schooling choices involves selection between entire distributions of wages rather than between alternative wage levels. Or this entails that a simple mean condition would be far from sufficient in order to attempt to measure anything, unless we always assume (no reason for it) Gaussian distributions. Therefore, an approach where the distribution per se is taken into account in its entirety should be based on quantile regressions technique and not on simple or augmented OLS. By supplementing the estimation of conditional mean functions with methodology for estimating an entire family of conditional quantile functions, the quantile regression technique is capable of providing a more complete statistical analysis of any stochastic relationship. Or this is exactly what we need to do in this context. The use of quantile

regression is not a novelty in the realm of the economics of education as such[7], although it has been hardly used in the choice of schooling and investment context. A test of risk compensation in wages can be implemented using quantile regression techniques. As far as we know, the only paper in this context is Pereira and Martins (2001). They do a quantile regression estimation of the Mincer equation and define risk as the difference in returns between its ninth and first decile. Using cross-country data (16 countries) they establish a positive correlation between risk and returns to education. Replicating this type of analysis for the data used for instance in Hartog, Oosterbeek and Teulings (1993), with the adaptations necessary, would perhaps would give more of a hint why the return to human capital in the Netherlands has fallen in the 80's in the Netherlands, while raising in most other countries (see above the discussion in the section on empirical evidence on risk in returns to schooling). Intuitively we expect that the returns have been decreasing only for the lower end of the skill distribution (using skill as a weak instrument for ability). One temporary drawback could be the fact that the if we are to use longitudinal data, quantile regression techniques have not been yet fully derived in this context, so we would be force to call our attention to cross-sectional analysis, which is often not that satisfactory.

Another motivating idea to work on is to first test empirically Hogan and Walker's (2001) model and secondly to try and modify this optimal stopping model so that stopping after completing a full degree requirement has a superior value to stopping in the middle of the program; of course this has more relevance in terms of the empirical implementation of the model to be estimated, where different weights might be attached to the reason for stopping the program (program completed, academic failure, personal reasons). Hogan and Walker's model is based on a very elegant methodology that could be empirically implemented as a maximum likelihood estimation technique. Once the appropriate data set is provided (the PSID for instance falls short of being feasible as far as we can tell), programming the likelihood would be the only cumbersome task. Quite a different and more difficult mission would be to extend Hogan and Walker's model so that the individual can stop

[7]Just to give an impression, several relatively recent studies have modelled the performance of students on standardized public exams as a function of socio-economic background characteristics such as parental income and educational attainment, and policy variables like class size, school expenditures, teacher's qualification; the importance of the quantile regression technique cannot be minimized here: it seems implausible that the covariates mentioned above could shift the entire distribution of test results by a fixed amount. It is more likely that the strongest students would be differently affected by a policy intervention than the students at the other end of the distribution.

and continue his previous or another educational program later. This would be somewhat in the spirit of the rationale in Belzil and Hansen (2002), although directly adapting their methodology or superposing it to Hogan and Walker's does not seem feasible. The financial option literature might provide though a solution for this quest–what we would need is to model the right to exercise repeatedly two options within an individual's lifetime: optimal stopping education to start working and optimal stopping working to start education again. In order to also include the possibility of specific training alongside working however, yet another model would be required. There are certainly many paths one should investigate in this peculiar context.

Related to the above paragraph and still included in the stream of research dealing with investment in education under risk, there is considerable work one can do starting from Hartog and Diaz-Serrano's (2002) model which we have shortly presented in the previous section. A primary goal is to re-estimate the model in the spirit the authors themselves do with the Spanish data, to see whether the empirical findings are confirmed. A further target would be to allow individuals to modify their initial plan in terms of schooling choice, since it is clear that most people do not have a clear idea of the length and type of education they would pursue when they make their first choice. We cannot appreciate at this moment however whether a full structural change is needed in this respect or whether the extension can be implemented with minor alterations. And finally, at the very end of the day, different types of education levels need to be considered. These are often specific to the country or even region where the data is collected from. The rationale for this extension would be to seek whether the risk is the same for instance in a professional school where the relation with the labour market is at least in principle expected apriori, and in a more academic setting (e.g. university) where one could see more uncertainty and more risk in choosing an optimal length or estimating a drop-out risk and so on and so forth. The skeleton for such an endeavour is however present, one simply needs to embellish it.

Last but certainly not least, we turn to risk attitude measurement. As one could see from reviewing the literature, estimating risk attitudes from revealed preferences (curvature of the utility function under expected utility theory) in a sort of structural model of choice under uncertain conditions, is often problematic and prone to measurement errors of all kinds. In spite of this, there is hardly any research dealing with direct measurement of risk attitudes. Why not asking the subjects simply their reservation prices for chosen lotteries in carefully designed surveys? The students entering secondary education can simply be asked about

their planned length of study and their expected first wage after entering the labour market. The same cross-section of students could be asked the same question when entering the next education level. And wages of all those entering labour markets, together with their schooling lengths could be recorded. This would directly indicate the subjects's perception concerning risk in investment in schooling. Of course a check on correspondence with actual choice behavior needs to be done; however it is not to be expected that the predictive validity of this survey methods is small (empirical data suggests that people have quite a fair idea of their starting wages in the labour market when asked this in school, an indication that they have an idea of their abilities albeit these are difficult to infer to the researcher). This stream of research is composed first of designing the right questionnaires and attaching them perhaps to some know, already existing surveys and only in the second step in analyzing the outcomes.

References

Ashenfelter, O., C. Harmon & H. Oosterbeek (1999), 'A review of estimates of the schooling/earnings relationships with tests for publication bias', *Labour Economics* **6**(4), 453–470.

Becker, G.S. (1964), *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, New York: NBER and Columbia University Press.

Belzil, C. & J. Hansen (2002), Earnings dispersion, risk aversion and education. IZA DP No. 513.

Chen, S. (2001), Is investment in college education risky? State Univ. of New York, discussion paper.

Diaz-Serrano, L., J. Hartog & H. Skyt Nielsen (2003), Compensanting wage differentials for schooling risk in denmark. working paper.

Dixit, A.K. (1989), 'Entry and exit decisions under uncertainty', *Journal of Political Economy* **97**(3), 620–38.

Eaton, J. & S. Rosen (1980), 'Taxation, human capital and uncertainty', *American Economic Review* **70**(4), 705–715.

Harmon, C., V. Hogan & I. Walker (2003), 'Dispersion in the economic return to schooling', *Labour Economics* **10**(2), 205–214.

Hartog, J., C.N. Teulings & H. Oosterbeek (1993), *Age, Wages and Education in the Netherlands*, Center for Economic Policy Research, Cambridge University Press, pp. 182–211.

Hartog, J., E. Plug, L. Diaz Serrano & J. Vieira (2003), 'Risk compensation in wages- a replication', *Empirical Economics* **28**, 639–647.

Hartog, J., H. Van Ophem & S. Raita (2003), How risky is investment in human capital? Working paper, University of Amsterdam.

Hartog, J. & L. Diaz-Serrano (2002), Earnings risk and demand for higher education: A cross-section test for spain. IZA DP 641.

Hartog, J. & W. Vijberberg (2002), Are wages really compensating for risk aversion and skewness affection? IZA DP 426.

Hogan, V. & I. Walker (2001), Educational choice under uncertainty. working paper UC Dublin/ U. of Warwick.

Kodde, M. (1985), Microeconomic Analysis of Demand for Education, PhD thesis, Erasmus University Rotterdam.

Levhari, D. & Y. Weiss (1974), 'The effect of risk on the investment in human capital', *American Economic Review* **64**(6), 950–963.

McGoldrick, K. (1995), 'Do women receive compensating wages for income uncertainty', *Southern Economic Journal* **62**(1), 210–222.

McGoldrick, K. & J. Robst (1996), 'The effect of worker mobility on compensating wages for earnings risk', *Applied Economics* **28**, 221–232.

Merton, R.C. (1979), 'Optimal consumption and portfolio rules in a continuous time model', *Journal of Economic Theory* **3**, 373–413.

Pereira, P.T. & P.S. Martins (2001), 'Is there a return-risk link in education?', *Economic Letters* **75**, 31–37.

Shaw, K. (1996), 'An empirical analysis of risk aversion and income growth', *Journal of Labour Economics* **14**(4), 626–653.

Trostel, P., I. Walker & P. Wooley (2002), 'Estimates of the economic return to schooling for 28 countries', *Labour Economics* **9**(1), 1–16.

Weiss, Y. (1972), 'The risk element in occupational and educational choices', *Journal of Political Economy* **80**(6), 1203–13.

Williams, J. (1979), 'Uncertainty and the accumulation of human capital under the life cycle', *Journal of Business* **42**(4), 521–548.

Willis, R.J. & S. Rosen (1979), 'Education and self-selection', *Journal of Political Economy* **87**(5), S7–S36.