

# MODERN RISK MEASURES FOR INDIVIDUAL HIGHER EDUCATION INVESTMENT RISK EVALUATION

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**Abstract:** *One of the reasons why people get degree and participate in organized education is that they want to raise their human capital or signal their inner abilities to future employers by sorting themselves out. In both cases they can expect return to their investment, because they can expect higher life-time earnings than those who do not have degree. In this paper we will refer this activity as higher education investment or education investment. In this paper the investment of the state into educating their citizens will not be considered. The question of this paper will develop the findings of Vona (2014). I suggested to introduce modern risk measures because individual risk-taking became a serious question. It was considered that modern risk measures can help to solve some issues with the relation of investment and risk. However before applying some measures from a different field of science, namely investment finance and financial mathematics, to another, economics of education, there must be a very careful consideration, because there are debate over these measures applicability even on their field of science. Value at Risk is not coherent and Expected Shortfall is only one of a great deal of possible tail loss measures. For this reason it will be discussed in detail how should we should adopt the measures, what kind of data is necessary for calculating this risk measures and what kind of new insight they can bring. With the aid of a numerical example it will be shown that with expected shortfall measure we can reflect some large losses, and potential high value of diversification. We show the value at risk based measure is not coherent and this means it points out something different in this environment. It is can be an indicator of loss in opportunities for high end returns.*

**Keywords:** *Value at Risk, Expected Shortfall, Education Investment, Higher Education, Risk Measurement*

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## 1. Introduction

The use of variance in the rate of return to education investment as the measure of risk is commonly accepted in education economic literature both theoretically and empirically. The suggested quantile-based measures in the title focus on short-term large losses. Value at Risk for example answers the question: “what is the maximum of loss incurred in the 95% of best cases of our portfolio over the next two weeks?” (Acerbi et al., 2002) The economics of education question of the same sort would sound something like “What is the maximum of loss incurred in the 95% best cases of employment track record 5 years after graduation?” This paper will discuss the legitimacy of such a question and the data requirement for answering such a question.

## 2. Types of Risk and Measurement

Since Markowitz (1952) the general risk-return dilemma of portfolio selection is the part of every introductory course in finance. A risk avoiding investor are willing to allocate larger share of its portfolio value to a risky asset only if it offers greater expected return than equivalent risk alternatives or offers less risk than equivalent expected return alternatives. Markowitz measured risk with variance of return. In that case we

understand risk as the possibility of alteration from the expected value. It is intuitive because the larger is the variance the less precise we can predict the future outcome, for this reason the investment is more risky. However real life investors evaluate the differences from the expected return differently based on the direction of the difference. If the return become larger then it was predicted it does not bother the investor, it is welcomed, on contrary negative differences bother the investor more, because it is money loss. If the investor has scarce resources then loss of resources can make future investments impossible. For instance if a bank does not have enough reserves for an extreme scenario they can go bankrupt and lose the money of the owners and depositors.

Risk was very carefully analyzed in a financial environment, and multiple sources of risk was differentiated. We introduce them based on Duffie and Singleton (2003) and Gouieroux and Jasiak (2010).

- Market risk: It's due to unexpected price changes over time. It is experienced when the investor holds assets that have liquid markets. It can be underestimated in a market expansion period. This underestimation usually leads to a phenomenon called market bubble.
- Credit risk: It's due to the default of a credit. If a bank or any kind of investor lends money through a financial product for a future stream of cash flows, there is always a possibility that the borrower stops the repayment. It can be because the borrowing firm or institute goes bankrupt or a person has no income at the time to pay back the credit. If the business of the lender depend on the repayment cash flow than default can create huge harm in business.
- Liquidity risk: if an investor holds a financial asset in a portfolio it has value only when it can be sold. There is a risk in finding counterparty when the asset does not have a liquid market, which means there are low number and low volume trades on the market. In this case the investor has to wait long time to find a counterparty for a transaction. If the investor is in great need of cash it is a risk.
- Operational risk and systematic risk: The first is internal organization risks like fraud or system failures, and the second is the risk of an economic meltdown or in other words a risk of a market crisis.

If these risk categories can be interpreted for education investment then we have the possibility to apply the measures used in finance for them. We will use the human capital interpretation of education because it is the most commonly used interpretation in economic literature.

When people buy education with investing their time, effort or even money by paying tuition, they invest in their human capital. In financial terms they build a portfolio of special skills, knowledge, practice and expertise in hope they can sell this portfolio in the future on the labor market. Human capital and the individual cannot be separated so it is different than selling a stock in a way, that human capital can only be sold by working for a company for a longer period of time. If we interpret education investment this way the above mentioned risk categories can be easily interpreted, however the possible concerns with this interpretations will be mentioned as well.

One of the characteristic difference between a financial investment and human capital investment is time and complexity. For example buying a stock has very clear costs and the return can be very easy to calculate when it has realized. However in case of education things are different. Getting a degree take years, and building a career is even longer. There is great difficulty in telling the cause-consequence relations and

connecting the cash flows with investment. For this reason people evaluate education in a comparative manner. Do people with higher education earn more than people with secondary school education? Do people with economic degree earn more than those with degree in engineering? Universities usually promote themselves by telling how successful their alumni is compared to other universities.

Market risk of education investment can be easily interpreted. There can be an unexpected change in the price of acquiring a given knowledge or skill. Tuition can go higher, the education material could be proven more time consuming to process than it was expected and so on. The demand for a given profession or a portfolio of skills can change over time.

Liquidity risk is part of the market risk. If there is no demand for given profession then who was trained for that job will not find job opportunities. There are several reasons for unemployment but where unemployment rates are high it is very likely that there are people, who are not just waiting for a better job opportunity. However we have to strongly consider as market illiquidity when graduates work in jobs that does not require their obtained skills. The Office for National Statistics (2013) of UK reported that in 2013 47% of the recent graduates were employed in non-graduate job. Even 34% of those who are on the labor market for 5 years work in non-graduate jobs as well. This signals two things. It takes time to sell the obtained skills, and there is a possibility that it cannot be sold. It is also a possibility that however the degree was not necessary for the job the employer choose the employee based on the assumption, that she will do a better job than a non-graduate, but this line of thinking leads us out from the human capital assumption we stated in the beginning of the paper

Credit risk of education investment are sensed by the student loan company. If the education investors experience illiquidity (unemployment or very low earnings) they can fail to repay their student loan. In the United States student loan default rates can reach 10-15% (Turner, 2012). Credit risk is crucial in financing because human capital cannot be a collateral, this could deter banks to give credit for education investment. Credit based financing is available for post-secondary education in most OECD countries (Chapman, 2006). In the United States the student loan household indebtedness reached 9% of total household debt (nyfed.org, 2013). However Lochner and Monge-Naranjo (2012) argues that this source of financial aid comes too late and there is credit constraints in lower level of education that hold back children from less fortunate families from education. Managing credit risk in their case could be a very important question for future economy.

Operational risk and systematic risk: Operational risk can be the health of the given individual, and systematic risk can be a labor market crisis.

In the rest of the paper we will focus on the market risk of education and liquidity risk as the possibility of large losses on education investment.

### **3. Comparison of financial investment and education investment data**

Two main characteristic makes risk measurement more difficult in case of education investment. The first characteristic is that human capital, so as the elements of it cannot be directly measured. If we assume that every individual holds a portfolio of skills and expertise just as an investor holds a portfolio of securities, then the problem is that the value of the portfolio is very hard to calculate in any given point in time. We cannot tell an individual's productivity until he starts to work in a given job. Even than it is difficult to tell as we now from the principal-agent dilemma. Rate of return to education calculations rely on the notion that an individual would earn the average earnings of a level lower education level if she would not attain given credentials. It can serve well if we calculate rate of return for the whole higher education, but if we think on personal level it became more and more problematic. Is it plausible that a given individual has to

give up the average secondary school degree holder's wage? We have no better approach yet for foregone earnings.

If we put the puzzle in financial terms, it is like measuring a portfolio's risk when we does not know how much it had cost, but we can only proximate it, we have partial information on the cash flow it will generate for the individual, and we does not know the elements of the portfolio. If consider more features of the individual, like social background, we can have more information.

The second is that the investment takes way longer period and the market works in a completely different way. In labor market there are very few cases when professions has announced prices. In private sector wages differ company by company. There is no such quotation that for how much an informatics degree holder with 3 years' experience can be hired. This prices are outcome of individual deals and can be vastly different even in the same moment in time. After a job contract is settled the wage will not change for a longer period of time, unless it changes rapidly with to zero. When somebody gets unemployed he loses his regular earnings, and in case of graduates the difference between previous earnings and the unemployment welfare can be huge. However such institutions as severance pay can make a transition from job to job easier.

Income data and earnings are surrounded with large economic interest, so data are collected by statistical offices and labor ministries, student loan organizations or other institutions. Those are mainly yearly data. The capital market works completely differently, the products has only one price, one can buy and sell product immediately, the costs are immediate and easy to calculate and the data are public and available on large quantity. The differences are summarized in Table 1.

**Table 1:** Comparison of labor market and financial market

	Labor Market	Financial Market
Price	Only portfolio prices can be known, and prices change slowly, or rapidly drop.	One product one prices
Costs	Lot of indirect costs (for instance accommodation), foregone earnings, difficult to measure, few available data	Simple and easy to measure
Changes	Contracted wages change slowly, rapid changes can occur	Prices change constantly, rapid changes can occur
Data availability	Less reliably, yearly	Maximum reliability, high frequency

Based on table 1 and chapter 1 we can model the labor market as a slowed down version of the financial market. Setting up a portfolio takes long period of time, obtaining the full value takes even longer, but prices changes slower as well.

Accepting this approach would allow us to calculate for example a 5-year Value at Risk or 5-year Expected Shortfall for education investment even though these measures are calculated for very short period in time in financial practice.

If a graduate does not find job after graduation, or find a job that does not require a degree and ends up a below average wage, than counting tuitions and foregone earnings we can assume he suffered losses. A Value at Risk would measure this. For longer time period the possibility of larger losses is less likely because the life-time earnings are naturally an increasing function of time. The first years are important for student loan repayment and other life investments. If someone suffers that kind of losses on their education investment that hurts her long term human conditions, for example she has to

default on student loan and postpone investments, then it something like a portfolio faces huge negative positions that dues to pay.

Policymaker's, student loan organizations and academic researchers should have a clear picture on such a risk.

First we have to define the value of an education portfolio of a given time. Human capital cannot be sold, so it will be a hypothetical value. The idea is the following what would an average earner with one level less degree would pay or should be paid for to take over a graduated persons investment position in a given point in time  $t$  if no future income would be expected? It contains foregone earnings, direct net cashflows under the study period and earnings after graduation all with time value calculated as well. The is shown in a more formal way in (1)

$$E_i = (-w_{i-1} - c_i + w_i)\delta^T \quad (1)$$

Where:

- $E_i$  is the value of an education portfolio in a given  $t$  point in time, and time starts when the graduate started  $i$  level of education
- $w_i$  is the row vector of the yearly income with graduate level  $i$  up to  $t$  point in time
- $c_i$  is the row vector paid yearly costs of earning a degree up to a point in time  $t$
- $\delta$  is a row vector of future value factors for each year up to  $t$

In order for future calculation we define in (2) based on Artzner et al. (1999) a measure for education investment risk: Education Investment Value at Risk (EIVaR) for a given  $\alpha$ .

$$EIVaR = -\inf\{E_i | P[E_i \leq E] > \alpha\} \quad (2)$$

Basically (2) tells us (loosely) we should consider the set of losses that will be experienced with less than a given probability, VaR is in fact a lower quantile of a distribution multiplied by minus one.

As we will see VaR can be criticized based on it does not valuates portfolio diversification as a risk management tool. We introduce another risk measure based on an existing financial risk measure. The  $\alpha$  expected shortfall on education investment should be (3)

$$ESEI = -\alpha^{-1}(E[E_i \mathbf{1}_{\{E \leq q_\alpha(E)\}}] + q_\alpha(E)[\alpha - P(E \leq q_\alpha(E))]) \quad (3)$$

Where:

$q_\alpha(E)$  is the lower  $\alpha$  quantile of  $E$  education investment distribution.

Expected shortfall is a coherent measure of risk and for this reason, it has a growing popularity (Acerbi and Tausche 2002).

#### 4. Analysis of Coherence in Case of Education Investment Risk

Acerbi and Tausche (2001) go as far as that a risk measure should not be called a risk measure if it is not coherent. The authors might get a little bit rhetorical when they said that, because they wanted to pressure that the celebrated, and even used by Basel Committee, Value at Risk (VaR) measure is not coherent as we will see it here as well.

A risk measure is coherent when it is monotonous; sub-additive; positively homogeneous and translation invariant.

If we take a  $G$  set of random variables. Then  $\rho$  risk measure is a mapping from  $G$  into  $\mathbb{R}$  and it is coherent if it has:

- Monotonicity: if  $X, Y \in G$  and  $X \leq Y \Rightarrow \rho(X) \geq \rho(Y)$
- Subadditivity: if  $X, Y, X+Y \in G \Rightarrow \rho(X)+\rho(Y) \geq \rho(X+Y)$

- Positive homogeneity: if  $\lambda > 0$  constant,  $X, \lambda X \in G \Rightarrow \lambda\rho(X) = \rho(\lambda X)$
- Translation invariant:  $\alpha \in R$  and  $X; X+\alpha \in G \Rightarrow \rho(X)+\alpha=\rho(X+\alpha)$
- Relevance: if  $X \in G; X \leq 0$  and  $X \neq 0 \Rightarrow \rho(X) > 0$  (Artzner et al 1999)

Coherence should be an important feature of an education investment function as well, however we should see that the most well known risk measure VaR is not significant because it is not subadditive.

We have think about what are these criterions mean for higher education investment. We will assume that  $G$  is the possible risky obtainable human capital portfolios. For easier discussion we will refer  $X$  and  $Y$  as two different person with two different human capital portfolios. Monotonicity means that if one type of human capital owner faces at least as good earnings possibilities as the other for every possible outcome in the future then the risk of the former should be less. Positive homogeneity means if something multiplies the earnings outcomes in every possible case, for instance inflation, or taxation, than it effects the risk measure with a same rate. For example if wages grow 1% every year no matter what, then we can expect that the risk measure will change with 1% as well. Translation invariance means that if an individual receives a constant money transfer, this will decrease with equal value the value of the risk measure as well. Relevance is simple means that if losses occur the risk measure must have appositive value.

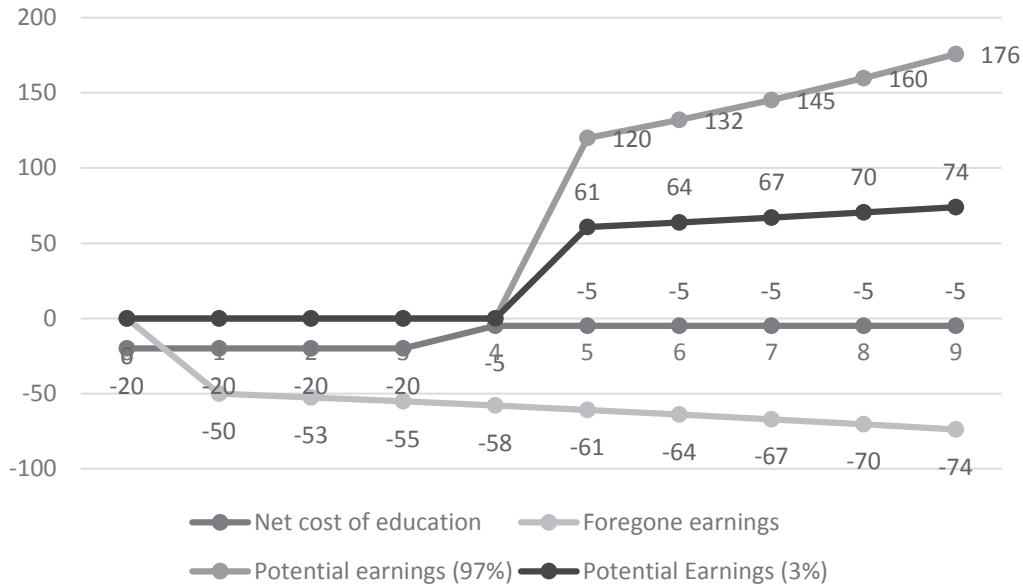
Subadditivity is the most interesting axiom for education investment. We stated that the elements value is impossible to measure. However we can have an intuitive approach to human capital diversification. If two person combine their income, for example by getting married and dividing their costs and earnings equally, then the risk measure should measure less risk for their combined household income than the sum for their individual incomes. Economics of marriage has a significant literature see for example Grosstbard-Schechtman (2003). Education investment risk diversification is not likely to be the strongest economic motivation but it can appear on a long list of other motivations. We will use this idea in the next chapter for a numerical example.

## 5. Example

In closing this discussion an example will be shown. Let's assume there is an individual "A" who attended a 4-year collage, and had an annual net cost of \$20.000 paid upfront every year, and after graduation, and from the moment he graduates he has to pay back his student loan in fix amount of \$5.000 in every year. "A" starts to work immediately after graduation and earns the first paycheck after the end of the first year. Assume there's two possibilities. I possibility  $G$ , "A" finds a graduate job that pays \$120.000 annually with a growth rate of 10%. If "A" would have not attended college, he would have started tow work in a non-graduate job were "A" would have earned \$50.000 annually with 5% growth rate. "A" has 3% probabily for not finding a graduate job and would have to take a non-graduate job with the current starting salary. 3% interest rate can be earned on risk-free deposits. Figure 1 shows the assumptions.

If we want to calculate the EIVaR for 5 years and 5% for "A" it would be \$24.908, because by using (1) "A" would has that value in 95% of time. However if that worst 3% of cases happens "A" has an education portfolio of -\$723,731 because the for year of collage cost are lost, the earnings and their potential interest is lost as well, and he has to pay back the student loan. The ESEI is -\$424,275. Table (2) summarizes the calculations.

Let's assume "A" married "B", when they started college together and they split costs and earnings as well equally. This is a diversification for "A" because now for half of her own human capital she receives the costs and benefits of "B"'s human capital. It is the same for "B" if they share household income equally. Moreover assume that "A"'s and "B"'s employment status is independent.



**Figure 1:** The data given in the example about “A”’s education investment

Let’s look at the per person income in the household. We can see this way they decreased the chance of the worst case scenario, because it is very unlikely they both end up in a non-graduate job. However it is not very visible in the variance of portfolio value statistic which decreased only slightly, whereas the ESEI show this effect clearly by dropping from \$424.275 to \$193.800, less than half of its original value. EIVaR on the other hand did not decreased at all, infect it increased. The probability that one of them will lose on an education investment is more than 5%. This means according to EIVaR it does not worth to diversify the portfolio. Is that make EIVaR a bad risk measure? No, infect it points out something important. Diversification can decrease the probability of high end positive outcomes as well. Maybe this is one of the reasons we do not see extremely many couples getting married in their early collage years.

**Table 2:** Calculation for the example

In case of diversification		In case of no diversification	
Probability	$E_i$ (in \$1000)	Probability	$E_i$ (in \$1000)
0,0009	-723,731	0,03	-723,731
0,0582	-184,086	0,97	24,90828
0,9418	24,908		
Expected Value	12,093	Expected Value	2,449
Standard deviation	12,332	Standard deviation	12,600
EIVaR(0,05)	184,086	EIVaR(0,05)	-24,161
ESEI(0,5)	193,800	ESEI(0,5)	424,2751

## 6. Conclusions and Recommendations

This paper gave examples for different risk measures for individual investment then variance in return. The most important conclusion is that these measures put more emphasis on low probability high loss situations that variance for example

does not emphasize. This would be interesting for those cases when higher education is more risky and can lead to default on student loan. This can be the case for those who come from a challenging social background (Hillman, 2014). Education should help those people the most. The future task is to calculate these measures for different datasets to have more information on human behavior toward education and risk.

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