# Human Capital Risk in Life Cycle Economies

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**Abstract**

I study the effect of market incompleteness on the aggregate economy in a model where human capital accumulation is risky. The environment is a general equilibrium life-cycle model with a version of a Ben-Porath (1967) human capital accumulation technology. A CARA-normal specification keeps household decisions independent of individual shock realizations. I study stationary equilibria of calibrated cases in which idiosyncratic uninsurable risk arises from *specialization risk*, which increases with investment in human capital, and *career risk*, which does not. With career risk only, stationary equilibria resemble those studied by Aiyagari (1994), and one concludes that the impact of uninsurable idiosyncratic risk is relatively small. But with a significant amount of specialization risk, stationary equilibria are severely distorted relative to a complete markets benchmark. One aspect of this distortion is that human capital is only about 43 percent as large as its complete markets counterpart. This suggests that the two types of risk have very different and quantitatively significant general equilibrium implications.

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# 1 Introduction

## 1.1 Human capital risk

Investment in human capital appears to be very risky. Carneiro, Hansen and Heckman (2003) find that the substantial heterogeneity in the returns to schooling is unpredictable at the time when schooling decisions are made. In related work, Cunha, Heckman, and Navaro (2005) conclude that 40% of the variability in the returns to schooling is unforecastable at the time students decide to go to college, implying that this uncertainty is not due to observable factors like ability differences or differences in initial conditions but purely due to idiosyncratic shocks.[1] In addition, it is widely understood that investment in human capital is uninsurable—there is a clear lack of complete markets with respect to this investment.

One main consequence of this type of labor income uncertainty is that it could deter investment in human capital, possibly leading to underaccumulation of human capital and overaccumulation of relatively less risky physical capital, in comparison to a case where agents can insure against this risk via complete markets. If a mechanism like this is at work in actual economies, the impact of market incompleteness on the aggregate economy may be immense,[2] possibly calling for policy intervention to mitigate the effect of this risk on household decisions to invest in training.[3]

I study the macroeconomic implications of labor income uncertainty arising from the risky nature of human capital investment. The specification here allows us to directly see the impact of risk on the process of human capital accumulation, isolate the impact of risk on individual decisions, and comment on divergent views in this literature on the role of

[1] Hartog, van Ophem, and Bagdechi (2004) find that human capital investment is so risky that investing in human capital is approximately equivalent to investing in the stock market with a portfolio of thirty randomly selected stocks They estimate that the risk associated with college education has a coefficient of variation of 0.3.

[2] Even more so if one takes the view that human capital is an engine of growth.

[3] Krebs (2003) comes to this conclusion in an endogenous growth model where investment in risky human capital is modelled as a portfolio decision and physical capital is the risk-free asset.

market incompleteness on the aggregate economy.

## 1.2 Main ideas

An important difference between investment in human capital compared to other assets is that it requires agents to allocate time away from the labor market when young and invest in education. Using a version of a Ben-Porath (1967) production function for human capital that allows for risky human capital, I study how uninsurable risk impacts an individual's decision to train in a general equilibrium life-cycle model. If the returns to training are uncertain and uninsurable, agents may try to self-insure by holding larger precautionary savings and, more importantly, endogenously altering their training decisions to mitigate the effect of risk. In this paper I follow the recent literature and abstract from the risks associated with physical capital investment.

Will it always be the case that human capital accumulation decisions will be decreasing in the level of idiosyncratic, uninsurable risk? In a general equilibrium model with only physical capital, Angeletos and Calvet (2006) include two types of uninsurable idiosyncratic uncertainty, labelled *entrepreneurial* and *endowment* risk. They show that, under some conditions, as endowment risk increases investment in risky physical capital *rises* in the steady state relative to complete markets benchmark. One of the main goals of this paper is to understand whether a similar mechanism may be relevant in a general equilibrium model of risky human capital. Like Angeletos and Calvet (2006), I consider two types of uninsurable idiosyncratic uncertainty, namely, *specialization risk* and *career risk*. Specialization risk increases with time devoted to training, while career risk is independent of the time input.

Higher risk is compensated by higher return, and higher return is often associated with higher levels of education. In my formulation of the returns from training, this aspect of education is captured by specialization risk. Considering this risk alone, when agents train more, they expect higher returns but they also face higher risk. But in the case of career risk,

when agents train more, they expect higher returns but face the same risk. Career risk is additive in the human capital accumulation technology and is the most common formulation in the literature studying the impact of idiosyncratic risk on the aggregate economy. Risks that look like the specialization risk of this paper were first introduced by Angeletos and Calvet (2006), but not in a human capital setting. When thinking of human capital, perhaps it is more natural to think that specialization risk plays a key role early in the life-cycle when agents are deciding to invest in training.

Market incompleteness arising because of these idiosyncratic uninsurable risks make the wealth distribution a relevant state for individual decisions, often making problems in this class intractable. Several papers, including Angeletos and Calvet (2006) and Angeletos (2006), use CARA-normal specification for preferences and risk in order to make an individual's risk taking decision independent of wealth. I employ the same technique along with certain other assumptions to ensure that an individual's decisions are independent of wealth. In the life-cycle model that I consider, there are both types of heterogeneity, within generation and across generation. Due to lack of wealth effects, within a generation all agents make identical decisions but differ in their labor quality, labor income, and consumption. Across generation heterogeneity is inherent in life-cycle models.

I study calibrated versions of the model to assess the quantitative importance of incomplete markets. Risk related parameters—the variances of the two shock processes in the human capital accumulation technology—are chosen to match the portion of the variance in labor earnings over the life-cycle that is due to age affects according to the literature. I study a baseline case which has a mixture of the two types of shocks, and also more extreme cases where there is either only specialization risk or only career risk.

### 1.3 Main findings

I first establish that the stationary equilibrium of my model with only career risk has properties similar to Aiyagari (1994). Aiyagari studied the macro-

economic impact of uninsurable idiosyncratic labor income risk in a model with no human capital and households which live forever. The career-risk-only case of the present model has implications similar to Aiyagari (1994).[4] In particular, risk and the precautionary savings it induces has only a small quantitative impact on macroeconomic variables.

I then study the baseline calibration where both shocks play a role. In the baseline calibration, all the variance in labor income early in life when agents are investing in training is due to specialization risk. Later in life, both risks play a role. I find that the effects of the specialization risk dominate and there is a very large impact on macroecomic variables in the stationary equilibrium. In particular, there is a 43 percent underaccumulation of human capital relative to the complete market case. Accordingly, since labor quality is dramatically lower, output, physical capital, consumption and other variables are also dramaticaly affected by the idiosyncratic uncertainty.

I conclude that uninsurable idiosyncratic specialization risk has a large impact on macroeconomic equilibrium, but that uninsurable idiosyncratic career risk does not.

Does human capital risk have a significant impact in actual economies? It may if the shocks resemble the baseline calibration. But if most of the risk in human capital investment is due to career risk, then the influence could diminish remarkably. In a way, the quantitative analysis nests both the views that are commonly seen in the literature, one following the tradition of Aiyagari (1994) that argues that the quantitative effects of incomplete markets are small, and a relatively recent view associated with Angeletos that suggests that these effects could be large.[5] One conclusion is that empirical studies based on micro data would need to identify these shocks in order to reach a conclusion about the role of incomplete markets.

Krebs (2003) is one analysis of the effects of risky human capital in a general equilibrium model. Krebs' formulation has agents that live forever

[4] This is despite the fact that there are no borrowing constraints in the present model.

[5] Neither of these authors talked explicitly about human capital.

and does not include a Ben-Porath type of model of human capital accumulation. Instead, human capital is a risky asset that can be accumulated in a manner similar to physical capital. The comparable stationary equilibrium in Krebs' (2003) analysis relative to the benchmark here has human capital is only 3.5 percent (of GDP) lower[6] and investment in physical capital is 5 percent higher relative to complete markets benchmark. According to the present analysis not accounting for the time allocation can lead to a gross underestimate of the impact of risk on human capital investment.

Apart from aiding our analysis in thinking about human capital investment and matching some of the salient features of the aggregate economy, the life-cycle model stays consistent with some of the features of the life-cycle model that are often studied in partial equilibrium setting, for example the shape of mean earnings and the variance of labor earnings.

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