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Risk aversion in a model of endogenous growth☆

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ABSTRACT

Despite the evidence on incomplete financial markets and substantial risk being borne by innovators, current models of growth through creative destruction predominantly model innovators' as risk neutral. Risk aversion is expected to reduce the incentive to innovate and we might fear that without insurance innovation completely disappears in the long run. The present paper introduces risk averse agents into an occupational choice model of endogenous growth in which insurance against failure to innovate is not available. We derive a clear negative relationship between the level of risk aversion and long run growth. Surprisingly, we show that in an equilibrium there exists a cut-off value of risk aversion below which the growth rate of the mass of innovators tends to a strictly positive constant. In this case, innovation persists on the long run and consumption per capita grows at a strictly positive rate. On the other hand, for levels of risk aversion above the cut-off value, the economy eventually stagnates.

1. Introduction

The outcome of the individual process of innovation is inevitably uncertain, and modern models of growth through creative destruction allow for such uncertainty. However, despite the fact there is wide evidence that agents are risk averse, these models assume that investment in R&D is not associated to any risk.[1] Common arguments for this simplification are that the risk inherent in performing R&D can either be perfectly hedged against, or that R&D is performed by risk neutral firms. In fact, perfect insurance against R&D risk is theoretically unlikely, due to problems of asymmetric information between innovators and investors, and/or problems of moral hazard (Akerlof, 1970; Arrow, 1962). Empirically, a funding gap for R&D has been well-documented even for developed economies, especially for small and new firms (for recent surveys, see Hall, 2002 or Hall and Lerner, 2010[2]), and capital markets appear to be imperfect, see, e.g., Card et al. (2007).[3]

The rate of technological progress and consequently the growth rate of consumption per capita crucially depend on the resources devoted to innovation. Without perfect capital markets to finance R&D, the level of risk aversion of agents is likely to impact on the allocation of resources and on the economy's long-run growth rate. The aim of the present paper is to analyze the extent of this impact.

Our model is based on Eaton and Kortum (2001) and Kortum (1997). Agents are born with an endowment of labor that they supply inelastically at birth. The length of an agent's life is uncertain. Following Yaari (1965) and Blanchard (1985), each agent faces a constant Poisson death rate. A fraction of the labor endowment is specific and can only be supplied to the production of output. Agents face a discrete occupational choice about the supply of their remaining labor: They can either work

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[1] See, e.g., Aghion and Howitt (1992), Grossman (1991b), Kortum (1997), Segerstrom (1998) and Segerstrom et al. (1990) for a non-exhaustive list.

[2] Further examples include Evans and Jovanovic (1989) who find evidence that wealth is positively linked to the likelihood of becoming an entrepreneur, and Caggese (2012), who empirically estimates that increased uncertainty has a large negative effect on risky investments by entrepreneurial firms.

[3] Incidentally, in neoclassical growth models, effects of imperfect insurance of income risk on growth have been analyzed quite extensively. See, e.g., Aiyagari (1994), Angeletos (2007), and the references therein. Generally, the literature has shown that while labor income risk increases precautionary savings, capital income risk can have an ambiguous effect on savings. In Aghion et al. (2010), tighter credit lowers mean growth through its effect on the cyclical composition of investment.

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in the production sector, or become researchers. While the wage in the production sector is certain, the returns of a researcher are uncertain, and in particular, an unsuccessful researcher does not earn any return. Successful researchers are compensated with the expected present value of their innovation.[4] Agents can smooth their consumption through saving, but as their entire income occurs at the beginning of their lives, they are unable to borrow. The assumption of a single income simplifies the analysis considerably, and allows us to abstract from wealth effects in the occupational choice decision.

The lack of insurance with respect to research success allows us to derive a clear and stark relationship between risk aversion and growth. We derive a cut-off value of risk aversion above which the economy stagnates. Consequently, there exists an upper bound on the stock of research and on average consumption per capita. These bounds are decreasing in the level of risk aversion. However, at or below this cut-off value, stagnation is not an equilibrium. On an asymptotically balanced growth path, both average consumption per capita and the level of technology grow without bounds. For levels of risk aversion strictly below the cut-off, on an asymptotically balanced growth path the measure of researchers will grow at a positive rate in the long run. This rate is increasing in the rate of population growth, though strictly below it, and decreasing in the level of risk aversion. To summarize, while risk aversion does indeed depress the growth rate of the economy compared to a risk neutral setting, even without any form of insurance complete stagnation of the economy does not necessarily occur.

The cut-off value we derive corresponds to a coefficient of relative risk aversion of unity. Empirically, the value of the coefficient of risk aversion (which in our model is the inverse of the intertemporal elasticity of substitution) is still debated. Many authors such as Campbell (1999), Kocherlakota (1996), Patterson and Pesaran (1992), Vissing-Jørgensen and Attanasio (2003), Alan and Browning (2010) or Alan et al. (2009) estimate coefficients of risk aversion well above unity, or equivalently, elasticities of substitutions below unity. See also Attanasio and Weber (2010) for a recent survey. On the other hand, Mulligan (2002) or Gruber (2006) estimate elasticities of substitution above unity, while the results of Gourinchas and Parker (2002) and Yogo (2004) are inconclusive. While our model remains agnostic about the empirical value of risk aversion, it does stress that the qualitative behavior of the economy in the long run critically depends on it.

Our model belongs to the endogenous growth literature,[5] and it is not our aim to provide a comprehensive review of this literature here. Within this literature, it is most closely related to recent contributions by García-Peñalosa and Wen (2008) and Zeira (2011), both of which model risk averse agents in occupational choice models.[6] Zeira (2011) models the endogenous formation of patent races for innovations of different levels of difficulty. In an extension, he introduces a model with finitely-lived agents and logarithmic utility in which some form of insurance is granted to innovators by assuming that they always work a fraction of their time in the production sector. He shows that risk aversion can lead to over-researching of "easy" innovations, as these are less risky, where riskiness is defined not over innovative success, but over winning the patent race. As such, both the environment and the question studied differ substantially from our paper. While Zeira (2011) focuses on the allocation of resources into different types of innovation, we study the choice between a production and a research sector. Foremost, however, the main contribution of our paper lies in deriving the relationship between the level of risk aversion and its qualitative effects on the economy (stagnation vs. growth). As in Zeira (2011) the level of risk aversion is fixed to unity, such a relationship is not derived.

García-Peñalosa and Wen (2008) are the closest to our own model, as their paper focuses on the effects of redistributive taxation on growth and inequality if agents are risk averse. They show that through insurance effects, redistributive taxes may indeed increase growth. This result is driven by the same intuition underlying our own results; the redistributive tax acts as a social insurance for unsuccessful innovators. The innovation process they model is built on Aghion and Howitt (1992), i.e. in contrast to us, they consider fixed inventive steps, a constant population, and the probability to innovate is independent of the stock of ideas. This implies that their model shares the prediction of strong scale effects of Aghion and Howitt (1992), and the growth rate of the economy is an increasing function of the number of researchers. As such, any variable that impacts the level of research, also impacts the growth rate of the economy. Within our model, we can separate effects on levels from effects on growth rates. Most importantly, García-Peñalosa and Wen (2008) focus on the importance of redistribution on growth, while our focus is on the interplay between risk aversion and the occurrence or lack of long-run growth. García-Peñalosa and Wen (2008) exclusively consider values of risk aversion that are below the cut-off value above which we find that the economy stagnates. We instead, are able to show that the existence of long-run growth hinges critically on the value of risk aversion.

Finally, our model is related, albeit less closely, to work on inequality in wealth and occupational choice under imperfect capital markets, such as Banerjee and Newman (1991), Banerjee and Newman (1993), and Galor and Zeira (1993).[7] While we share with this literature the assumption of imperfect capital markets, conceptually we differ substantially. In the above literature, imperfect capital markets affect outcomes because agents are *ex ante* heterogeneous in wealth. In our model, agents are homogeneous in endowments and the lack of capital markets affects the growth rate through a lack of insurance.

The remainder of the paper is organized as follows. Section 2 introduces the optimization problem of consumers in the economy, while Section 3 details the production side of the economy, including the innovation process and the value of R&D. Our results on equilibrium growth rates are derived in Section 4. Section 5 concludes.

2. Consumers

2.1. Endowments

The economy is populated by a mass L_t of agents, with a (gross) population growth rate $n \geq 0$. Following Yaari (1965) and Blanchard (1985), each agent faces a Poisson death rate of

[4] An important aspect in the innovation and patent literature is the question of appropriability of innovations. In our model, a successful innovator can perfectly reap the benefits of his innovation.

[5] Such as Romer (1986), Romer (1990), Aghion and Howitt (1992), Grossman (1991b), Segerstrom (1998), Jones (1995), Jones (2005), Kremer (1993), or Alcalá and Ciccone (2004), for a non-exhaustive list. Some very good overviews of the main theories of endogenous growth can be found in, e.g., Barro and Sala-i-Martin (2003), Grossman and Helpman (1991a), Aghion and Howitt (1998) and more recently Acemoglu (2009).

[6] Also related, though not dealing with risk aversion as such, are Cozzi and Giordani (2011), who study *ambiguity aversion* of innovators and find that higher ambiguity aversion leads to lower R&D efforts.

[7] See also Aghion and Bolton (1997), Ghatak and Jiang (2002), or Mookherjee and Ray (2003) and the references therein.