Entrepreneurial Risk, Investment and Innovation*

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Abstract

In this paper I develop a general equilibrium model with risk averse entrepreneurial firms and with public firms. The model predicts that an increase in uncertainty reduces the propensity of entrepreneurial firms to innovate, while it does not affect the propensity of public firms to innovate. Furthermore, it predicts that the negative effect of uncertainty on innovation is stronger for the less diversified entrepreneurial firms, and is stronger in the absence of financing frictions in the economy. In the second part of the paper I test these predictions on a dataset of small and medium Italian manufacturing firms.

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Introduction

This paper studies the effect of undiversifiable entrepreneurial risk on innovation. Entrepreneurs have traditionally been considered an engine of innovation and technological progress for the economy. More recently economists have begun to recognize that the behaviour of entrepreneurial households is important for aggregate economic fluctuations because these households account for a substantial share of aggregate investment, production and savings. This paper is motivated by two facts, which have been emphasized in this recent literature. First, entrepreneurial households appear to be poorly diversified. Moskowitz and Vissing-Jørgensen (2002) analyze US data and show that 48% of all private equity is owned by households for whom it constitutes at least 75% of their total net worth. Bitler, Moskowitz and Vissing-Jorgensen (2005) provide evidence that agency considerations play a key role in explaining why entrepreneurs on average hold large ownership shares. Second, empirical evidence generally finds entrepreneurs to be as risk averse, and some studies find them to be even more risk averse than non entrepreneurs (Sarasvathy, Simon and Lave, 1998; Miner and Raju, 2004; Hongwei and Ruef 2004).

The presence of a large amount of undiversifiable risk influences the relationship between uncertainty and portfolio choices of entrepreneurial households (Heaton and Lucas, 2000). The objective of this paper is to analyze the consequences of this risk for the willingness of entrepreneurial firms to undertake risky and innovative projects. The hypothesis is that, because entrepreneurial households have most of their wealth invested in their own firm, their main instrument to rebalance the risk/return profile of their assets in response to a change in uncertainty, is the choice of the riskiness of the firm's investment projects.

I test this hypothesis both theoretically and empirically. I develop a model of a general equilibrium entrepreneurial economy. Each entrepreneur is infinitely lived and can invest in its own business or can borrow or lend at the risk free rate. The business produces output using fixed capital, which is subject to depreciation shocks that generate an exogenous volatility of profits. The entrepreneur also has the possibility to innovate the technology of the business by paying a fixed cost. I consider both the case in which the innovation improves the productivity with probability one, called "technology adoption", and the case in which the innovation improves the productivity if successful but it reduces it if unsuccessful, called "risky innovation". The idiosyncratic risks of fixed capital investment and of risky innovation are not insurable.

In the model I also introduce a corporate sector, where the firms are identical to the entrepreneurial firms, except that the investment decisions of the corporate sector firms are taken by risk neutral managers. I solve the general equilibrium of the model in the absence of aggregate uncertainty, but in the presence of idiosyncratic uncertainty for both the entrepreneurial firms and the risk neutral firms. I simulate the artificial economy and calibrate it so that the cross sectional variance of the income/sales ratio and the amount of undiversifiable risk in the simulated entrepreneurial sector matches the same moments calculated for US entrepreneurial households.

The simulation results determine the following predictions: i) an increase in uncertainty, as measured by the volatility of profits, reduces the propensity of entrepreneurial firms to invest in "risky innovation", while it does not affect the propensity of risk neutral firms. This negative effect is found to be quite strong despite the fact that the innovation shock is uncorrelated with the profits shock. ii) The negative effect of uncertainty on innovation for entrepreneurial firms is stronger the less diversified they are, and the lower is the presence of financing frictions in the economy. iii) A change in uncertainty does not affect the investment in "technology adoption" for all firms.

In the second part of the paper I test these predictions on a dataset of small and medium Italian manufacturing firms. This dataset includes detailed information about the ownership structure of the firms and the innovation content of firm investment. The estimation results are consistent with all the predictions of the model.

This paper is related to Czarnitzki and Kraft (2004), who study the innovation of owner-led firms versus managerial firms. Furthermore, this paper is related to the literature on undiversifiable entrepreneurial risk and entrepreneurial decisions. In particular Heaton and Lucas (2000) study the implications of entrepreneurial undiversifiable risk for portfolio choices and asset prices. Rampini (2004) and Caggetti and De Nardi (2006) develop general equilibrium models where financing imperfections and undiversifiable risk affect the decision to become an entrepreneur, and illustrate the consequences for aggregate fluctuations and growth. Finally, this paper is related to the literature about general equilibrium economies with heterogenous entrepreneurial households and incomplete markets (Quadrini and Meh, 2006; Angeletos, 2006; Covas, 2006, among others).

This paper makes a new contribution to the literature by showing that undiversifiable entrepreneurial risk affects the relationship between uncertainty and innovation. More specifically, this paper makes a theoretical contribution by analyzing simultaneously the investment in fixed capital and in innovation in a general equilibrium entrepreneurial economy with incomplete markets. The simulations of the model show that the negative effect of uncertainty on innovation is significant for realistic levels of undiversifiable risk. Another interesting theoretical finding is that uncertainty significantly affects fixed capital investment and innovation only for financially unconstrained entrepreneurial firms. This prediction is confirmed by the empirical analysis in the second part of the paper. It implies that the understanding of the uncertainty-innovation relationship can be useful to disentangle the effects of precautionary behaviour from those of financing constraints on the investment decisions of firms.

The other major contribution of this paper is that it provides empirical evidence concerning the link between uncertainty and the innovation decisions of entrepreneurial versus non entrepreneurial firms. The dataset used is particularly interesting, as it combines balance sheet data with survey data. The balance sheet data covers a large panel with more than 10000 Italian manufacturing firms. The survey data covers the same firms, and it includes detailed qualitative information about the property structure, about the investment in innovation, and about other relevant qualitative information that can be used to control the robustness of the results, such as the presence of financing constraints, the degree of internationalization and the market structure of the firms.

The outline of this paper is as follows: section I illustrates the model. Section II shows the results of the simulations of a general equilibrium entrepreneurial economy. Section III shows the empirical analysis of the Italian manufacturing firms. Section IV summarizes the conclusions.

I The model

I consider an economy with a large number of firms and an identical number of households that manage them. Firms are all ex ante identical, and have access to a technology that produces using fixed capital. In addition to investing in fixed capital, firms can also try to innovate to improve their technology. Firms are also subject to idiosyncratic shocks, which cause exogenous fluctuations in profits. The objective of the theoretical section of this paper is to study how changes in the volatility of the exogenous shocks affect the willingness of entrepreneurial firms to invest in risky innovation.

In the model I assume that a fraction γ of firms is managed by entrepreneurial households. Each of these households can either invest in their own firm or borrow or lend a one period riskless bond. I call these households the "entrepreneurial sector".

A fraction (1-γ) of firms is managed by the remaining households. The difference is that these households can invest in each other's projects (but not in the entrepreneurial sector), and are able to perfectly diversify their risk. I call these households "diversified" and the corresponding firms the "corporate sector". Without loss of generality I assume that all diversified households own the same uniform portfolio in the shares of the firms in the corporate sector. These diversified households can also trade the one period riskless bond with the entrepreneurial households.

I introduce the "diversified" households and the "corporate sector" in the model for two reasons. First, because they allow to simulate an artificial economy where the degree of concentration of risk of the entrepreneurial households is comparable to the level observed in reality. If only the entrepreneurial sector were present in the economy, the entrepreneurial households would not be able to diversify much of their idiosyncratic risk, and it would be much more difficult to match the empirical data. Conversely the diversified households are willing to sell risk free debt to the entrepreneurs, allowing them to better diversify their risk. Second, because the comparison of the behaviour of entrepreneurial firms with the behaviour of the corporate sector firms allows me to isolate and quantify the effect of entrepreneurial risk on investment and innovation.

As in Abel and Eberly (2005) I assume that the firms can, by investing a fixed cost, update their technology to the frontier. In order to preserve the stationarity property of the maximization problem I assume that the technology frontier is constant. If a firm does not innovate, its technology depreciates with a positive probability and drifts away from the frontier, because of obsolescence. Below I describe the investment decisions of the firms in the entrepreneurial sector and in the corporate sector.

A The entrepreneurial sector

At time t a generic entrepreneurial firm produces output y_t using the following production function:

$$y_t = A_t k_t^{\alpha}; 0 < \alpha < 1 \tag{1}$$

where k_t is capital and A_t is the technology level. I introduce in the model an indicator function I_t, which is equal to one if the entrepreneur invests in innovation by paying a fixed cost F, and zero otherwise. If the entrepreneur does not innovate ($I_t = 0$) then with probability ϕ technology depreciates at the rate δ_A. The value of ϕ can be interpreted as the probability that a competitor of the firm successfully innovates its technology.[1]

If the firm invests in innovation ($I_t = 1$), it succeeds with probability ξ, and its technology reaches the frontier $\overline{A}$. With probability $1-\xi$ innovation fails, and technology reaches the lower bound $\underline{A}$. This outcome can be interpreted as the firm having abandoned the old technology, which was possibly not cutting edge but moderately successful, to develop a new technology, which turns out to be unsuccessful and less profitable than the existing one. The dynamics of technology conditional on innovation are summarized

[1] The parameter ϕ is mainly included for technical reasons. A small value of ϕ allows to calibrate the model with a relatively small number of discrete states of the technology level A_t. In the next section I show that such assumption is not essential for the results, which hold also for the case of deterministic depreciation of technology ($\phi = 1$).

below:

if $I_t = 0$ then: $A_{t+1} = \max[\underline{A}, (1-\delta_A) A_t]$ with probability ϕ
A_t with probability $1-\phi$

if $I_t = 1$ then: $A_{t+1} = \overline{A}$ with probability ξ
$A_{t+1} = \underline{A}$ with probability $1-\xi$

The value of ξ determines two types of innovation. If $\xi = 1$ we can interpret the $I_t = 1$ decision as "technology adoption". The firm pays a fixed cost to adopt a new technology which, with probability one, will allow it to produce more efficiently. Instead if $\xi < 1$ the $I_t = 1$ decision can be interpreted as "risky innovation".

The cost of innovation is fixed from the point of view of the entrepreneur, but it is a function of the expected profits generated by innovation in the steady state:

$$F = g\pi(r) \tag{2}$$

where g is a constant, r is the return on the one period riskless bond, and $\pi(r)$ are the average profits generated in one period after upgrading the technology by a risk neutral firm.[2]

The timing of the model is as follows. At the beginning of time t, the firm produces y_t and repays the debt b_t contracted in the previous period. Net worth is:

$$w_t = y_t + (1-\delta_t) k_t - b_t \tag{3}$$

The depreciation rate of capital δ_t is the source of exogenous uncertainty for the firm. It follows an i.i.d. symmetric Markow process:

$$\delta_t = \delta + \varepsilon_t \tag{4}$$

$$\begin{aligned} \varepsilon_t &= \theta(S_t) \text{ with probability } 0.5 \\ \varepsilon_t &= -\theta(S_t) \text{ with probability } 0.5 \end{aligned} \tag{5}$$

[2] Condition (2) ensures that the fixed cost F is always proportional to the expected return from innovation in the economy.

$$0 < \theta(S_t) \leq \delta \tag{6}$$

The volatility regime S_t will be described below. The variable ε_t can be interpreted as a shock on profits. Another way to generate the same effect would be to introduce e^{ε_t} as a multiplicative factor in the production function. The advantage of the formulation in (4)-(6) is that, because fixed capital k_t is frictionless, an increase in the volatility of ε_t increases the volatility of profits without directly affecting the expected productivity of capital. On the contrary an increase in a multiplicative technology shock would simultaneously increase both the volatility of profits and the expected return on capital, because of the concavity of the production function. This would make it more difficult to isolate the effect of uncertainty on the investment decisions of entrepreneurial firms for a given level of expected productivity.

Finally, equation (6) implies that the volatility of the ε_t shock is a function of the regime S_t, which follows a two state persistent stochastic process:

$$S_t \in \{S_H, S_L\} \tag{7}$$

$$prob(S_t = S_{t-1}) = \rho \tag{8}$$

$$prob(S_t \neq S_{t-1}) = 1 - \rho \tag{9}$$

$$0.5 < \rho < 1 \tag{10}$$

$$\theta(S_H) > \theta(S_L) \tag{11}$$

Condition (11) implies that the volatility of profits is higher in the S_H state than in the S_L state. For simplicity, I rule out the presence of aggregate uncertainty by assuming that the regime S_t is firm specific.

The purpose of the next section of this paper is to simulate the model and to verify how the investment and innovation of entrepreneurial and risk neutral firms are affected by the level of exogenous uncertainty. One could argue that the introduction of the switching regime S_t is an unnecessary complication, because one could simply solve the model for a constant θ and then compare the simulation results for different values of θ. However such simpler exercise would compare different steady states with different characteristics, and would not be directly comparable to the empirical investigation performed in the second part of the paper, where I study how uncertainty affects innovation decisions at the firm level. For example, the simulations of the model with switching regimes take also into account the fact that the propensity to save and the wealth of entrepreneurial households change conditional on the state S_t.

After producing, the firm decides the consumption of the household c_t, the level of fixed capital that will be productive in the next period k_{t+1}, the amount to be borrowed or lent, and wether or not to pay the fixed cost and upgrade the technology. The budget constraint is the following:

$$c_t = w_t + \frac{b_{t+1}}{R} - FI_t - k_{t+1} \tag{12}$$

$$R \equiv 1 + r \tag{13}$$

b_{t+1}/R is the net present value of the face value of debt b_{t+1}, to be repaid in the next period. It is subject to the following borrowing constraint:

$$b_{t+1} \leq \bar{b} + \tau k_{t+1} \tag{14}$$

$$\bar{b} \geq 0; \tau \geq 0 \tag{15}$$

Given the presence of incomplete markets, constraint (14) is included in order to avoid that b_t grows unbounded over time. However in the benchmark calibration of the model I set $\overline{b}$ and τ large enough so that the investment of the firm is virtually never financially constrained. I do so for two reasons. First, because the main objective of this paper is to identify the effect of risk aversion on innovation and to distinguish it from the effects of other factors such as borrowing constraints. This strategy is feasible from the point of view of the empirical tests performed in the second part of this paper, because I use a dataset that contains qualitative information about the financing problems faced by the firms, and allows to control for the possible effect of borrowing constraints. Second, in the model financing constraints affect entrepreneurial firms very differently from the way they affect risk neutral firms in the "corporate sector". A risk neutral firm that maximizes profits and faces a tight borrowing constraint may retain all earnings and quickly accumulate enough financial wealth to become unconstrained. An entrepreneurial firm that maximizes intertemporal utility cannot pursue the same strategy, because of consumption smoothing considerations. As a consequence a simulated economy where borrowing constraints are binding for a non negligible share of firms makes the comparison between entrepreneurial firms and risk neutral firms very problematic.

The entrepreneurial firm chooses b_{t+1}, k_{t+1} and I_t in order to maximize the value function (16) subject to constraints (12) and (14):

$$V\left(S_t, w_t, A_t\right) = \max_{I_t,} \left\{V^{up}\left(S_t, w_t, A_{t+1}\right), V^{noup}\left(S_t, w_t, A_{t+1}\right)\right\} \tag{16}$$

where:

$$V^{up}\left(S_t, w_t, A_t\right) = \left\{\max_{k_{t+1}, b_{t+1}} u\left(c_t\right) + \beta^e E_t\left[V\left(S_{t+1}, w_{t+1}, A_{t+1}\right)\right] \mid I_t = 1\right\} \tag{17}$$

$$V^{noup}\left(S_t, w_t, A_t\right) = \left\{\max_{k_{t+1}, b_{t+1}} u\left(c_t\right) + \beta^e E_t V\left(S_{t+1}, w_{t+1}, A_{t+1}\right) \mid I_t = 0\right\} \tag{18}$$

By taking the first order condition of (17) and (18) with respect to k_{t+1} and b_{t+1} it is possible to derive, conditional on the upgrade decision, the following first order conditions for k_{t+1} and b_{t+1}:

$$u'(c_t) = \beta^e E_t \left[\left(\frac{\partial y_{t+1}}{\partial k_{t+1}} + 1 - \delta_{t+1} \right) u'(c_{t+1}) \mid I_t \right] \tag{19}$$

$$u'(c_t) = R\beta^e E_t \left[u'(c_{t+1}) \mid I_t \right] \tag{20}$$

Equation (19) can be used to determine the optimal amount of fixed capital k_{t+1} :

$$k_{t+1} = \left\{ \frac{E_t (A_{t+1} \mid I_t)}{UK - R\beta^e \left\{ cov \left[\left(\frac{\partial y_{t+1}}{\partial k_{t+1}} + 1 - \delta_{t+1} \right), u'(c_{t+1}) \mid I_t \right] / u'(c_t) \right\}} \right\}^{\frac{1}{1-\alpha}} \tag{21}$$

where:

$$UK = R - 1 + \delta \tag{22}$$

The covariance term $cov \left[\left(\frac{\partial y_{t+1}}{\partial k_{t+1}} \right) + 1 - \delta_{t+1}, u'(c_{t+1}) \mid I_t \right]$ is negative, and it reduces the optimal amount of capital k_{t+1}. It represents the risk premium induced by risk aversion with respect to the uncertainty in δ_{t+1} and A_{t+1}. The risk of innovation is also reflected in the term $\{E_t [V (S_{t+1}, w_{t+1}, A_{t+1})] \mid I_t = 1\}$ in equation (17). The higher is the volatility of A_{t+1} conditional on innovating, the higher is the variance of future consumption, which will be very high in case of success but very low in case of failure, the lower is the expected utility from consumption and the value of $\{E_t [V (S_{t+1}, w_{t+1}, A_{t+1})] \mid I_t = 1\}$. This effect reduces the incentive to innovate for an entrepreneurial firm with respect to a risk neutral firm, and it will be quantified in section II.

B The corporate sector

Firms in this sector are identical to those described above. The only difference is that they are managed with the objective to maximize the net present value of the stream of profits V_t^d:

$$V_t^d(S_t, A_t) = \max_{k_{t+1}^d, I_t^d} E_t\left(\pi_{t+1}^d\right) + \frac{1}{R} E_t\left[V_{t+1}^d\left(S_{t+1}, A_{t+1}\right)\right] \tag{23}$$

where:

$$E_t\left(\pi_{t+1}^d\right) = E\left(y_{t+1}^d\right) - UKk_{t+1}^d - RI_t^d F \tag{24}$$

Therefore their optimal investment is as follows:

$$k_{t+1}^d = \left\{\frac{E_t\left(A_{t+1}^d \mid I_t^d\right)}{UK}\right\}^{\frac{1}{1-\alpha}} \tag{25}$$

Because all firms are ex ante identical, and each household owns an equally weighted portfolio, the dividends d received each period are equal to the average of the profits $\pi_t^d(S_t, A_t)$:

$$d = \int \pi_t^d(S_t, A_t)\, d\Gamma^d(S_t, A_t) \tag{26}$$

The absence of aggregate uncertainty implies that $\Gamma^d(S_t, A_t)$, the density function of risk neutral firms, is constant, and therefore also d is constant over time. Therefore the problem of a generic diversified household is the following:

$$\max_{c_t^d, b_{t+1}^d} \sum_{j=0}^{\infty} \left(\beta^d\right)^j u\left(c_{t+j}^d\right) \tag{27}$$

such that:

$$c_t^d = w_t^d + d + \frac{b_{t+1}^d}{R} \tag{28}$$

Finally, b_{t+1}^d is bounded by the following condition:

$$b_{t+1}^d \leq \frac{Rd}{r} \tag{29}$$

Equation (29) states that the diversified households cannot borrow more than the net present value of their flow of dividends.

C General equilibrium

In the following definitions I use the subscripts i and j to indicate the $i-th$ entrepreneurial household and the $j-th$ diversified household respectively. The equilibrium of the economy is: a value function for the entrepreneurial firm $V_{i,t}(\theta_{i,t}, w_{i,t}, A_{i,t})$, and for the risk neutral firm $V_{j,t}^{d}(S_{j,t}, A_{j,t})$; the policy functions $k_{i,t+1}(S_{i,t}, w_{i,t}, A_{i,t})$, $b_{i,t+1}(S_{i,t}, w_{i,t}, A_{i,t})$ and $c_{i,t}(S_{i,t}, w_{i,t}, A_{i,t})$; the diversified households' borrowing b^{d} and consumption c^{d}; the cross sectional distribution of entrepreneurs' characteristics $\Gamma(S_{j,t}, w_{j,t}, A_{j,t})$ and the interest rate r_t such that:

i) Given r_t, the entrepreneur's policy functions solve the entrepreneur's decision problem (16), and the diversified household policy functions' solve the diversified household's decision problem (27).

ii) The interest rate r ensures that the bond market is in equilibrium:

$$\gamma \int b_{t+1}(S_{i,t}, w_{i,t}, A_{i,t})\, d\Gamma(S_{i,t}, w_{i,t}, A_{i,t}) + (1-\gamma)\, b^{d} = 0 \tag{30}$$

iii) The cross sectional distribution of entrepreneurs' characteristics $\Gamma(S_{i,t}, w_{i,t}, A_{i,t})$ and of risk neutral firms' characteristics $\Gamma^{d}(S_{j,t}, A_{j,t})$ are constant over time.

In order to ensure that in equilibrium entrepreneurial households face a non negligible amount of undiversifiable risk, I assume that entrepreneurs are relatively impatient:

Assumption 1: $\beta^{d} > \beta^{e}$

When equation (30) holds, the consumption path of the diversified households is constant over time ($c_{j,t}^{d} = c_{j,t+1}^{d} = c^{d}\ \forall j, t$), and the equilibrium interest rate is $R^{*} = \frac{1}{\beta^{d}}$. Intuitively, suppose that assumption 1 does not hold, because $\beta^{d} = \beta^{e}$, and that $R = \frac{1}{\beta^{d}}$. For this value of the interest rate the entrepreneurs, as long as they face idiosyncratic risk, are willing to invest in the risk free bond for precautionary reasons. This reduces R below

$\frac{1}{\beta^d}$, and it incentives the diversified households to borrow in order to increase consumption. This accumulation of debt by the diversified households continues until either the entrepreneurial sector has saved so much that is able to fully diversify the risk, or until the diversified households have reached their maximum borrowing allowed by equation (29). On the contrary assumption 1 ensures that entrepreneurs save up to the point that their desire to save in order to diversify their risk is counterbalanced by their desire to consume due to their relatively low discount factor.

II Simulation results

I solve the maximization problem of the entrepreneurial firm and of the risk neutral firm using a numerical method (see appendix 1 for details), and I simulate an artificial economy. I model utility with a C.E.S. function:

$$u(c_t) = \frac{c_t^{1-\eta}}{1-\eta} \tag{31}$$

Table I illustrates the choice of benchmark parameters. The expected depreciation rate of fixed capital δ is set equal to 14.5%. β^d is set to match an average real interest rate of 3%. The fraction γ of entrepreneurial households in the economy is equal to 0.4.[3] The parameters $\theta(S_H)$, $\theta(S_L)$, α and β^e are calibrated on annual data of the entrepreneurial households in the 1989, 1992, 1995 and 1998 US Surveys of Consumer Finances (SCF). The parameter α determines the curvature of the production function and can be interpreted as the degree of market power of the firm. I calibrate it to match the average of the net profits/sales ratio for the entrepreneurial businesses in the SCF. The parameters $\theta(S_t)$ and β^e match the degree of concentration of risk of US entrepreneurial households.

[3] The value of γ does not affect the results as long as it is not too large. If the fraction of diversified households $1-\gamma$ is to small, constraint (29) may be binding in equilibrium, and it may become impossible to clear the bond market.

More specifically, the average variability of the ε shock $\frac{\theta(S_H)+\theta(S_L)}{2}$ matches the standard deviation of the net income/sales ratio for the entrepreneurial businesses in the SCF.[4] The difference between $\theta(S_H)$ and $\theta(S_L)$ and ρ, the persistency of the S_t regime, are chosen so that the standard deviation of the profits/sales ratio is on average 20% higher in the high volatility state than in the low volatility state. The parameter β^e matches the wealth distribution of the entrepreneurial sector. Following Moskowitz and Vissing-Jørgensen (2002) I measure it as the ratio between the value of the business and the total net worth of the household. The larger the ratio is, the more the profits of the business are an important component of the permanent wealth of the household, the more the household is sensitive to changes in business risk for its consumption and investment decisions. I choose β^e in order to match the fraction of total private equity that is owned by households for which the value of the business constitutes at lease 75% of their total net worth.[5] Moskowitz and Vissing-Jørgensen (2002) calculate this fraction to be around 48%. The assumptions of the model establish a direct mapping between this moment and the value of β^e. If β^e decreases, entrepreneurial households are willing to consume more and to borrow more, and their distribution of financial wealth shifts to the left.

The frontier technology $\overline{A}$ is normalised to 1. The parameters ξ, δ_A, $\underline{A}$ and ϕ jointly determine the frequency and the risk of innovation. In the benchmark calibrations I choose $\underline{A}$=0.61, or 61% of the frontier technology. This value implies that the risk of innovation accounts for around 30% of the total volatility of profits.[6] Moreover I choose ξ in order

[4] The cross sectional volatility of this ratio is actually equal to 0.18 for these businesses, but such high value may overestimate the true volatility of profits, as it could also be driven by unobserved heterogeneity across businesses. Since the higher is the parameter θ the stronger are the findings of the simulations, I conservatively choose a value which is half of empirical estimate.

[5] Given the assumption of incomplete markets, the model does not imply an objective market value of an entrepreneurial business. Instead I compute it as its certainty equivalence for the entrepreneur. Nonethless using more objective masures of the value of the business, such as the net present value of the expected profits, does not affect the results obtained in this section.

[6] This is calculated as the difference between the overall volatility of profits and the volatility of profits conditioal on not choosing to innovate.

to match the average frequency of innovation observed for the non entrepreneurial firms in the sample analyzed in the next section.

Finally, I set $\phi = 0.05$, meaning that technology depreciates on average every 20 periods, and δ_A is on average equal to 0.057, meaning that depreciation implies a 35% fall in average profits. Obviously there exist many possible combinations of ϕ and δ_A that imply exactly the same expected depreciation in technology. I chose a relatively small value of ϕ for convenience, because it implies a large value of δ_A and it reduces the number of discretised points in the space of the state variable A_t, making the computation of the several simulated economies presented in the next section more manageable. One problem with this choice is that, since technology depreciates in discrete intervals, it follows that a range of values of $\delta_A \in \left(\underline{\delta_A}, \overline{\delta_A}\right)$, rather than a single value, is consistent with the matched moments. However, the specific value of δ_A may affect the risky innovation choice of entrepreneurial firms. Therefore I simulate several types of firms with different values of δ_A in the $\left(\underline{\delta_A}, \overline{\delta_A}\right)$ range, and calculate the average effect of uncertainty on risky innovation for these firms. The problem with this approach is that, the smaller is ϕ, the larger is the interval $\left(\underline{\delta_A}, \overline{\delta_A}\right)$. Even though this should not affect the validity of the qualitative findings of the simulations, it may make the quantitative findings (the elasticity of the probability to innovate with respect to a change in exogenous uncertainty) less precise. In order to control for this problem, in the next section I compare the benchmark results with the results of a simulation with $\phi = 1$ and with a much narrower interval $\left(\underline{\delta_A}, \overline{\delta_A}\right)$.

The parameter g in equation (2) matches an estimate of the average cost of innovation. I consider the sample of Italian firms analyzed in the next section, and I calculate the cost of labour related to innovation using the information about the fraction of employees that are engaged in $R\&D$ in the firms. Multiplying this fraction for the total labour cost, I calculate that the labour cost of innovation is on average equal to 1.2% of the value of the firms assets. Assuming that labour cost is 1/3 of all costs related to innovation, then g is set so that the ratio of F over total assets is equal to 3.75%.

The relative risk aversion coefficient η is set equal to 2, and the parameters $\overline{b}$ and τ that determine the tightness of the collateral constraint (14) are set at a level high enough so that entrepreneurial firms are never financially constrained. In the following tables I verify the sensitivity of the results to different values of these parameters.

Table II illustrates the relationship between capital, innovation and uncertainty in the simulated economy for the benchmark parameters. The table is divided in two sections. The "risky innovation" section corresponds to the benchmark parameters illustrated in table I. The risk of innovation is actually driven by three parameters: the fixed cost of innovation F, the probability that innovation fails $1 - \xi$ and the lower bound value of technology. The smaller is ξ, the longer is the expected time necessary to innovate. While the firm keeps trying, it has to pay the fixed cost F and moreover it can only produce with the low productivity level $\underline{A}$. Therefore, conditional on the values of F and $\underline{A}$ the lower is ξ, the more costly innovation is, and the longer the firm uses the current technology and delays innovation. It follows that the lower is ξ, the larger is the distance between the current productivity A_t and $\overline{A}$ and the larger is the volatility of the permanent income of an entrepreneurial firm that decides to innovate.

The "technology adoption" section instead assumes that innovation is successful with probability one ($\xi = 1$). However innovation is still risky in the sense that once the technology is upgraded, the firm will have to invest more in fixed capital, and such investment is risky because of the stochastic depreciation of capital and technology. In this section I calibrate the fixed cost F so that the expected cost of upgrading the technology to the frontier is the same with respect to the risky innovation case.[7] Moreover I change the value of δ_A so that the frequency of innovation is approximately the same in both cases. Under this new parametrization it also follows that the difference between the frontier technology $\overline{A}$ and the value of A_t at which firms on average innovate is much smaller than in the "risky innovation" case. Therefore I also lower the value of $\overline{A}$ so that firms on average innovate for comparable values of A_t in the two simulations.

For both the "risky innovation" and the "technology adoption" sections I illustrate the statistics computed for all the observations and the statistics computed conditional on low volatility of profits ($S_t = S_L$) and on high volatility of profits ($S_t = S_H$). The first four rows report the information about the volatility of profits relative to sales. The "high uncertainty" row refers to a simulation where both the average $\frac{\theta(S_H)+\theta(S_L)}{2}$ and the difference across states $\theta(S_H) - \theta(S_L)$ is higher than in the benchmark case.

The next three rows report the information about the return on capital. Notice that the investment decisions of risk neutral firms are, by construction, not affected by the amount of uncertainty, and therefore have identical statistics in the benchmark case and in the high uncertainty case. However the presence of risk neutral firms is useful. The comparison between them and the entrepreneurial firms allows to precisely measure the effect of risk aversion and precautionary saving on the investment decisions of entrepreneurial firms. For example the table shows that in the case of "risky innovation" and high uncertainty the return on capital is on average approximately 6% higher for entrepreneurial firms than for risk neutral firms. As expected, the return on capital is also substantially higher when $S_t = S_H$ than when $S_t = S_L$. Regarding the "technology adoption" economy, here return on capital is on average higher because in this simulated economy firms do not have to

[7] The expected cost of upgrading the technology to the frontier is equal to $F\frac{1+r}{r+\xi}$.

experience periods of low productivity while trying to innovate. Another consequence is that the precautionary saving effect is smaller. For example in the high uncertainty case the return on capital is on average only 2.7% higher for entrepreneurial firms than for risk neutral firms. The next three rows report the information about the average amount of capital. As expected precautionary saving reduces the investment in fixed capital. For example in the high uncertainty case capital is 10% lower for entrepreneurial firms than for risk neutral firms.

Finally, the bottom of the table reports the information about innovation. In the case of risky innovation it is found that entrepreneurial firms innovate less on average than risk neutral firms. Importantly, their innovation decisions are significantly affected by the amount of uncertainty. The frequency of risky innovation of entrepreneurial firms is 4% higher conditional on ($S_t = S_L$) than conditional on ($S_t = S_H$) in the benchmark simulation, and is 8% higher in the simulation with higher uncertainty. These values correspond to an elasticity of the probability to innovate with respect to the standard deviation of the profits/sales ratio equal to -0.2. This finding is perhaps surprising given that the innovation shock and the background uncertainty (the ε shock) are independent. However it is consistent with the theoretical findings of Gollier and Pratt (1996), who show that under certain conditions risk averse agents are "vulnerable" to risk. Among other thing "risk vulnerability" implies that "*adding an unfair background risk to wealth makes risk averse individuals behave in a more risk averse way with respect to another independent risk*".[8] A sufficient condition for "risk vulnerability" is decreasing and convex risk aversion, which is satisfied by CARA and CRRA utility functions. This condition is

[8] Gollier and Pratt (1996) consider risks that are entirely unrelated with each other, while in the case of my model I have outcomes (the innovation outcome and the depreciation of capital) that are contemporaneously uncorrelated but are dynamically related, because if innovation is succesful the firm invests in more capital and also implicitly increases the magnitude of the future expected depreciation risk.

realistic, because it implies that the wealthier an agent is, the smaller is the reduction in risk premium of a small risk for a given increase in wealth.

Importantly, the level of background risk does not significantly affect the innovation in the economy with "technology adoption". The frequency of innovation is approximately identical in both the low risk and the high risk states. This result does not depend on the fact that in this economy the difference between the frontier technology $\overline{A}$ and the value of A_t at which firms on average innovate is very small. I simulated alternative economies with technology adoption where the fixed cost F is so large that the difference between the frontier technology $\overline{A}$ and the value of A_t for an innovating firm is the same as in the "risky technology" economy. In this case I found that entrepreneurial firms innovate more rather than less than risk neutral firms, and marginally more in the high risk state than in the low risk state. This is exactly the opposite of what happens in the "risky innovation" economy. The reason is that, when $\xi = 1$ and innovation is not risky the fixed cost F is a safe investment, because it generates higher return in the next period with certainty. Therefore the larger is F in the "technology adoption" economy, the more innovation becomes desirable for risk averse entrepreneurs.[9]

Before I argued that a small value of ϕ is useful because it increases the computational speed in solving the investment problem. In order to show that the assumption of stochastic depreciation of A_t is not necessary to generate the negative effect of uncertainty on risky innovation, in table III I compare the benchmark simulation with a simulation where technology depreciates at a deterministic rate ($\phi = 1$). In the new simulation the parameters F, ξ and δ_A are calibrated so that the value of A_t for an innovating firm and the frequency of innovation are approximately the same as in the benchmark case. While

[9] The simulation results with higher values of F are available upon request.

computationally much more expensive (the state space of A_t is seven times larger than in the benchmark case), this simulation also reduces the interval $\left(\underline{\delta_A}, \overline{\delta_A}\right)$, and it allows me to check whether this approximation is important for the qualitative results illustrated in table I. Table III shows that risky innovation is still significantly negatively affected by uncertainty also in the case of deterministic depreciation. Notably, the sensitivity of innovation to the volatility regime is almost as large as in the benchmark calibration.

Table IV reports the sensitivity of the above results to different levels of the relative risk aversion coefficient η. It shows that, even though the sensitivity of entrepreneurial risky innovation to uncertainty is higher the more risk averse entrepreneurs are, it is still present even for low values of risk aversion.

One possible objection concerning the robustness of the negative effect of uncertainty on risky entrepreneurial innovation is that in the model entrepreneurs are not allowed to choose less risky businesses. One could then argue that, even though the empirical evidence shows that on average entrepreneurs are as risk averse as non entrepreneurs, it may be that high risk businesses are managed by less risk averse individuals, and vice-versa. In order to control for this factor, the "mixed types" rows in table IV refer to simulations with heterogenous entrepreneurial types, where less risk averse entrepreneurs manage high risk businesses, and vice-versa. The simulation results still show a significant negative effect of uncertainty on entrepreneurial innovation, especially in the high uncertainty case.

Finally, the bottom part of table IV reports the innovation statistics for less diversified and more diversified entrepreneurs. I define as diversified those observations for which entrepreneurs have accumulated enough financial wealth w_t so that this constitutes at least 50% of their total net worth, which is measured as the certainty equivalence value of the business V_t^M plus w_t. It follows that for these observations the value of the business is equal or less than 50% of their total net worth. The undiversified entrepreneurs are the complementary sample. Their frequency of innovation is on average higher simply because most of the innovation takes place when the firm hits the lower bound $\underline{A}$ and while it tries to innovate every period it runs down its wealth w_t. More interesting is the comparison of the sensitivity of innovation to uncertainty for diversified and undiversified entrepreneurs. Table IV shows that such sensitivity is always much larger for undiversified entrepreneurs than for diversified ones. The explanation is that wealth accumulation reduces the importance of the background risk for the consumption decisions of entrepreneurial households, and thus also reduces the effect of uncertainty on risky innovation. In other words, the more wealthy a firm is, the less the idiosyncratic risk of the business matters, the more the firm behaves as a risk neutral firm. This result confirms the intuition that uncertainty may be an important factor in explaining entrepreneurial innovation decisions not just because entrepreneurs are risk averse, but also because most of them do not diversify the idiosyncratic risk of their business.

Less intuitive and more interesting are the results illustrated in table V. Here I compare the benchmark economy with economies where the coefficient τ of the collateral constraint (14) is sufficiently low so that the fixed investment of a fraction of entrepreneurial firms is financially constrained in equilibrium. The first two columns replicate the benchmark result, where $\tau = 0.9$ and no firm is financially constrained. The next two columns consider a value of $\tau = 0.3$, which corresponds to having 25% of financially constrained firms. The final two columns consider a value of $\tau = 0$, which corresponds to having 50% of financially constrained firms.

As expected, financing constraints reduce average capital and increase the return on capital in the economy, due to its decreasing marginal returns. Moreover the presence of financing frictions lowers the frequency of risky innovation. This happens despite the financing constraint is never binding for a firm which is currently trying to innovate.[10] Innovation is instead deterred by future expected financing constraints, because the lower is τ, the larger is the downpayment needed to finance fixed investment. If financial wealth w_t is low, the firm expects its future fixed investment to be financially constrained, and therefore expects not to be able fully exploit the advantage of a successful innovation, and thus finds innovation to be less profitable ex ante.

Surprisingly, table V also shows that financing constraints dampen the negative relationship between uncertainty and innovation, so that this is almost completely eliminated in the more constrained economy. The explanation is simple. In the benchmark simulation entrepreneurial firms with very low financial wealth w_t are not financially constrained and their investment decisions are determined by the optimality condition (21). This condition implies that uncertainty matters more the less diversified the firm is. Therefore the lower is wealth, the higher is the sensitivity of risky innovation to the amount of background risk.

On the contrary, in the simulations with smaller τ, entrepreneurial firms with low w_t are financially constrained and their investment decisions are determined by their availability of funds rather than by the optimality condition (21).

III Empirical analysis

The simulations of the general equilibrium entrepreneurial economy illustrated above determine the following testable predictions:

[10] An innovating firm expects its productivity to be low, because the probability to fail is high. As a consequence, it will choose a small amount of fixed capital k_t.

Prediction I: An increase in uncertainty, as measured by the volatility of profits, negatively affects the risky innovation of entrepreneurial firms, while it does not affect the risky innovation of non entrepreneurial firms.

prediction I^{bis}*: An increase in uncertainty does not affect the risky innovation of diversified entrepreneurial firms and/or of financially constrained entrepreneurial firms.*

Prediction II: An increase in uncertainty does not affect the technological adoption of both entrepreneurial and non entrepreneurial firms.

I test these predictions on a dataset of small and medium Italian manufacturing firms based on the 1995, 1998 and 2001 Mediocredito Centrale Surveys. Each Survey covers the activity of a sample of more than 4400 small and medium manufacturing firms in the three previous years. Mediocredito Centrale selected these samples balancing the criteria of randomness and continuity. Each survey contains three consecutive years of data. After the third year, 2/3 of the sample is replaced and the new sample is then kept for the three following years. The information provided in the surveys includes detailed qualitative information on property structure, employment, R&D and innovation, internationalization and financial structure. In addition to this qualitative information, Mediocredito Centrale also provides, for most of the firms in the sample, an unbalanced panel with some balance sheet data items going back in time as far as 1989.

This dataset has several useful features. First, it includes direct qualitative information not only on the amount spent by each firm in R&D, but also on the type of fixed investment and R&D expenditure. This information can be used to identify which firms are investing in projects that involve risky innovation.[11] Second, it includes information about the

[11] Other authors have been analysing the innovation data of the Mediocredito Surveys. Hall, Lotti and Mairesse (2006) study the relationship between employment, innovation and productivity. Parisi, Schiantarelli and Sembebelli (2006) study the relationship between productivity, innovation and R&D. Benfratello, Schiantarelli and Sembenelli (2006) analyse the effect of banking development on firm innovation.

property structure of the firms, which allows to identify which firms are "entrepreneurial", in the sense that they are owned and managed by the same individual. Third, it includes additional information that can be used to control for the effect of other factors that are potentially important for innovation, such as financing constraints, market structure and internationalization.

The main limitation of this dataset is the lack of information about the assets of the entrepreneurial households that are not included in the balance sheet of the firm. On the one hand this is not a problem for the test of predictions I and II. On the other hand prediction 1^{bis} implies that the negative relationship between risk and innovation is driven by the firms in the sample that do not diversify the risk. In the following sections I will show some empirical evidence in support of this prediction using the information about the financial assets of the firms.

A Construction of the dataset

I select the sample of entrepreneurial firms using the following property structure information from the surveys. Firms are asked if their three largest shareholders: i) are individuals, financial companies or industrial companies; ii) have the direct control of the firm. Finally, for each of these shareholders is specified their share of ownership in the firm.

Using this information I select as "entrepreneurial" those firms that: a) have one individual that owns at least 50% of the shares of the firm; b) are actively managed by this individual.

In the model the entrepreneurial households own 100% of the shares of their firms. Therefore criterion (a) may seem too weak. However I argue that this is not the case, and that this selection criterion is the most efficient in identifying "family firms" that effectively are fully owned and managed by a single entrepreneurial household. This claim can be verified using the information provided by the 1995 survey, where firms also indicate, in case more than one shareholder is an individual, whether there are family ties among them (unfortunately this information is not included in the 1998 and 2001 surveys). I consider the firms classified as entrepreneurial firms in the 1995 survey, according to the criteria (a) and (b). Among all the entrepreneurial firms that have more than one shareholder, 94% have other individuals as shareholders, and 71% have family ties among all the shareholders.

In the full sample composed of the three surveys, 33.2% of the firms are classified as entrepreneurial. The sorting criterion is fairly stable over time, so that if I exclude from the entrepreneurial group those firms that are present in more than one survey, and are not selected as entrepreneurial firms in all the surveys, the ratio falls very little, from 33.2% to 30.2%. Table VI illustrates some summary statistics about the firms in the dataset. Entrepreneurial firms are on average younger, smaller, and they have a marginally higher return on capital.

B Estimation strategy

I identify the investment in innovation using the direct questions in the Mediocredito Surveys. In the section with the heading "Technological innovation and R&D", firms are asked whether they engaged, in the previous three years, in R&D expenditure. The firms that answer yes (37% of the total) are asked what percentage of this expenditure was directed to: i) improve existing products; ii) improve existing productive processes; iii) introduce new products; iv) introduce new productive processes; v) other objectives.

Furthermore, in the section of the survey with the heading "Investment", firms are asked if they undertook new investment in plant and/or equipment in the three previous years. The firms that answer yes (89% of the total) are asked to specify to what extent the fixed investment had the following objectives: i) improve existing products; ii) increase the production of existing products; iii) produce new products; iv) other objectives. For each chosen answer the firm indicates three possible degrees of intensity: low, medium and high.

I use the questions above to construct indicators of risky innovation activity. It is plausible to assume that on average the innovation related to the introduction of new products is likely to be risky, because of demand uncertainty. Conversely the innovation directed either to improve existing products or to innovate the productive processes is less risky, and analogous to the technology adoption case considered in the simulations. It is important to notice that this mapping between the innovation decision in the model and in the empirical data is consistent with the view that product innovation may be chosen by the firm as part of a diversification strategy. In fact also in the model the investment in risky innovation is a diversification opportunity, because its outcome is independent from the ε shock . However, the simulations of the model show that such independent risks interact in a significant way. They show that, for realistic levels of concentration of entrepreneurial wealth, an increase in one of the two independent risks significantly reduces the willingness to take on the other risk.

Therefore, I summarize the information about innovation and technology adoption in the four following variables. The variable that identifies risky innovation is $r\&d\_inn_{i,p}$, which is equal to 1 if more than 50% of $R\&D$ spending of firm i in survey p is directed to develop new products, and zero otherwise. $r\&d\_t.a._{i,p}$, the variable that identifies "technology adoption" (less risky innovation) is equal to 1 if firm i did $R\&D$ activity in survey p and $r\&d\_inn_{i,p} = 0$, and zero otherwise. An alternative indicator of risky innovation is $fix\_inn_{i,p}$, which is equal to 1 if fixed investment spending of firm i is partly or fully directed to the introduction of new products, and is equal to 0 otherwise. Finally $fix\_t.a_{i,p}$ is equal to 1 if firm i undertook a new fixed investment project but $fix\_inn_{i,p} = 0$ and 0 otherwise. Table VII reports the percentage of firms selected according to the five criteria above. It shows that entrepreneurial firms on average engage less in R&D than non entrepreneurial firms. Moreover a similar proportion of firms in both groups invests in fixed capital in order to improve existing products or to introduce new productive processes, while entrepreneurial firms on average are less likely to introduce new products.

Before testing the predictions of the model, I provide some anecdotal evidence in support of the claim that the innovation variables selected above are correlated with the average riskiness of the firms in the sample. The model predicts that conditional on innovating a firm expects an higher volatility of its future revenues. Figures 1-3 show the correlation between the average volatility of profits across firms in each 3 digit sector and the frequency of the different types of innovations. Figure 1 shows that on average sectors with an higher fraction of firms doing R&d also have an higher cross sectional dispersion of returns. Figures 2 and 3 show that the dispersion of returns is also increasing in the ratio of product innovation over process innovation. These unconditional correlations are consistent with the claim that product innovation is on average more risky than the innovation directed to improve the current production.

C Estimation results

I test predictions 1, 1^{bis} and 2 by regressing the two dichotomous variables representing the "risky innovation" decision $r\&d\_inn$ and fix_inn, and the two dichotomous variables representing the "technology adoption" decision $r\&d\_t.a.$ and fix_t,a, on a measure of idiosyncratic uncertainty:

$$
\begin{aligned}
y_{i,p} &= \alpha_0 + \alpha_1 risk_{i,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} + \alpha_4 constrained_{i,p} + \\
&\quad + \alpha_5 return_{i,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age_{i,p}^2 + d_{i,p}^{2digits} + d_{i,p}^{survey} + u_{i,p}
\end{aligned}
\tag{32}
$$

The dependent variable $y_{i,p}$ is one of the indicators of innovation described above. The independent variable $risk_{i,p}$ is the indicator of idiosyncratic uncertainty. I include in the regression also the following control variables: $return_{i,p}$, which is an indicator of the average profitability of firm i. This variable is important, because it controls for the possibility that higher uncertainty may affect innovation indirectly by increasing the average expected return.[12] $export_{i,p}$ is equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. The variable capturing market structure is $supply_{i,p}$, which is equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms, and equal to zero otherwise. The variable capturing financing constraints is $constrained_{i,p}$, which is equal to one if firm i declares financing constraints (14%), and zero otherwise.[13] The other control variables are $size_{i,p}$, which is the number of employees of firm i, and $age_{i,p}$, which is the age of firm i (relative to the year of the survey) measured in years. Finally, $d_{i,p}^{2digits}$ is a series of two digit sector dummy variables, and $d_{i,p}^{survey}$ is a series of survey dummy variables. Unless otherwise specified, all the estimations presented below are with the standard errors clustered at the 3 digit sector level.

Table VIII reports the estimation of equation (32) where the measure of uncertainty

[12] This possibility is ruled out in the simulations by construction, because uncertainty affects the volatility of profits but not the expected productivity of capital.

[13] Firms are asked the three following questions about financing problems: 1) "during the last year, did the firm desire to borrow more at the interest rate prevailing on the market?". 2) "If the previous answer was yes: was the firm willing to pay and higher interest rate in order to get additional credit?". 3) "During the last year, did the firm ask for more credit without obtaining it?". The variable $constrained_{i,p}$ is equal to one if the answer to any of the three previous questions is positive.

$risk_{i,p}$ is equal to $roa\_stdev\_6_{i,p}$, which is the standard deviation of the gross income/assets ratio for firm i in the six years before survey p. For example if firm i is surveyed by the 1995 Mediocredito Survey, $roa\_stdev\_6_i$ is relative to the 1989-1994 period. For consistency the variable $return_{i,p}$ is equal to the average gross income/assets ratio for firm i in the six years before survey p, called $roa\_avg\_6_{i,p}$. The regression results in table VIII confirm prediction 1, because they show that risk negatively affects the innovation of entrepreneurial firms. For these firms, the coefficient of $roa\_stdev\_6_i$ is negative and significant both using $r\&d\_inn_i$ and fix_inn_i as dependent variables (columns 1 and 5). Conversely the same coefficient is much smaller and not significantly different from zero for the other firms. Furthermore table VIII is also consistent with prediction 2, because risk does not significantly affect the innovation that is related to the improvement of the existing production (dependent variables $r\&d\_t.a_i$ and $fix\_t.a._i$).

One obvious problem with using $roa\_stdev\_6_i$ as a measure of idiosyncratic risk is its endogeneity. Some firms may innovate more than other firms on average, and as a consequence they may also be more risky. Therefore in table IX I consider an exogenous measure of uncertainty, the variable $sdroa\_1_{s.p}$. This variable is equal to the cross sectional standard deviation of the return on assets for the firms in the three digit sector s in the most recent year of survey p (e.g. year 1994 for the 1995 Survey).[14] $sdroa\_1_{s,p}$ varies both across sectors and across surveys, and it has 191 different observations in total. Even though this variable is exogenous from the point of view of the single firm, it may still be affected by sector specific omitted variables. The robustness of the results to this potential problem are analyzed in the next section.

[14] I consider the most recent available year of each survey as it includes an higher number of observations. This is because not all firms have balance sheet data for all the three years in the survey. Nonetheless the results do not differ substantially if I consider a cross sectional measure of risk that covers all the three years in the survey instead.

As control variables I include the same ones included before, except for $return_{i,p}$,which is now equal to the cross sectional mean of the return on assets for each sector, called $avgroa\_1_{s,p}$. The results shown in table IX confirm again predictions 1 and 2. An increase in uncertainty measured by the $sdroa\_1_{s,p}$ variable has a significant and negative effect on the investment in risky innovation of the entrepreneurial firms, while it does not affect the investment in risky innovation of the other firms. Importantly, while entrepreneurial and non entrepreneurial firms differ with respect to the correlation between risk and innovation, they do not differ much with respect to the significance of the other control variables. With respect to the regressions that use $r\&d\_inn_{i,p}$ and $fix\_inn_{i,p}$ as dependent variables, I find that firms that export more and larger firms innovate more. Conversely firms that produce based on orders of downstream firms rather than for the market innovate less. These findings may be explained by the fact that large firms that produce for the market and that export abroad are more pressured to innovate by their own competitors.

Conversely, the regressions that uses $fix\_t.a._i$ as the dependent variable show that firms that install new fixed capital to improve the existing production have opposite characteristics: they export less and they produce more upon orders and less for the market.

D Robustness checks

In this section I perform several robustness checks of the consistency between the predictions of the model and the empirical evidence.

D.1 Financing constraints and diversification

The first robustness check is related to the prediction of the model that the presence of financing constraints reduces the negative effect of uncertainty on the risky innovation of entrepreneurial firms. Table X replicates the analysis in table IX after excluding the 14% of firms that declare financing problems in any of the three surveys. The results are consistent with the predictions of the model. The comparison between tables IX and X shows that excluding financially constrained firms increases the negative effect of uncertainty on risky innovation. Moreover the bottom part of table X shows that the negative effect of risk on innovation disappears when the model is estimated for financially constrained firms only.

The second robustness check is related to the prediction of the model that the negative effect of uncertainty on risky innovation only holds for undiversified entrepreneurial households. More precisely, simulation results show that the entrepreneurial households that hold an amount of financial assets relatively large with respect to the size of their business are not substantially affected by changes in uncertainty. In order to verify this prediction I construct the following measure of the financial assets of the firm. The variable $fin\_a_{i,t}$ is equal to the ratio between the net financial assets of firm i (financial investment + liquidity + short term financial credit - short term financial debt) divided by the total assets of firm i in period t. I eliminate the largest 1% and smallest 1% values as outliers. The measure of diversification I consider is $divers_{i,p}$, which is the average of $fin\_a_{i,t}$ across the three years of survey p. The mean of $divers_{i,p}$ is equal to 0.38, and its standard deviation is equal to 0.21. I verify prediction I^{bis} in table XI, where I estimate equation (32) using the risky innovation indicators $r\&d\_inn_{i,p}$ and $fix\_inn_{i,p}$ as dependent variables and separating firms according to the value of the variable $divers_{i,p}$.

The 0.5 cutoff point is chosen because the simulation results indicate that at this level of financial wealth an entrepreneurial firm is sufficiently diversified so that, unless it is very risk averse, its innovation decisions are no longer affected by changes in uncertainty. I also estimate the model for firms with $divers_{i,p}$ higher than 0.75. This higher threshold for diversified entrepreneurial firms is justified by the fact that the measure of diversification is computed in the simulated data using the value of the firm's future profits at the denominator. Instead in the empirical data this is substituted with the book value of the assets, which is likely to underestimate the real value of the firm. The estimation results confirm the prediction that the negative effect of risk on innovation is driven by the undiversified entrepreneurial firms. The coefficient of $sdroa\_1_{s,p}$ becomes not significant for high levels of diversification as measured by the variable $divers_{i,p}$. Importantly, also in this case there are few substantial variations in the coefficients of the other main determinants of innovation across the different regressions.

As I argued above, these results are unlikely to be driven by the fact that low $divers_{i,p}$ firms are financially constrained firms, because both the model and the regression results above show that financing constraints reduce rather than increase the negative effect of risk on the innovation decisions of entrepreneurial firms. This is confirmed by table XII, which splits the sample in the same way as table XI but also it excludes from the sample financially constrained firms. In this case the coefficient of $sdroa\_1_{s,p}$ becomes more significant and larger in absolute value for "low $divers_{i,p}$" firms.

D.2 Endogeneity problems

In the previous section I argued that the uncertainty measure $sdroa\_1_{s,p}$ is exogenous from the point of view of the single firms, while it may still be correlated to sectorial characteristics that may cause endogeneity and omitted variable problems in the estimation of equation (32).

This section verifies that the observed negative relationship between uncertainty and entrepreneurial innovation is not driven by such unobserved characteristics. It is worthwhile to notice that the results presented above already provide two argument to reject such claim. First, the test of the model is based on finding a differential effect of uncertainty on the different types of innovation decisions of entrepreneurial versus non entrepreneurial firms. The results confirm this differential effect, and find that the only significant negative effect of uncertainty on innovation regards the innovation to develop new products by entrepreneurial firms, as predicted by the model. Therefore any endogeneity problem that biases the coefficient of $sdroa\_1_{s,p}$ in the same direction for all firms and for all types of innovation cannot explain this finding.

Second, the most likely endogeneity problem in the estimation of equation (32) is that some firms may belong to more dynamic sectors, with more innovation on average and also higher volatility and cross sectional dispersion of profits. But this type of endogeneity should bias the coefficient of $sdroa\_1_{s,p}$ upwards rather than downwards, and therefore it should bias the estimations towards rejecting rather than accepting prediction 1. This claim is confirmed by table XIII, which estimates the effect of uncertainty with and without including the set of control variables. The first five columns estimate the model with $r\&d\_inn_{i,p}$ as dependent variable. In column (1) no control variable is included. In column (2) I include only the sector and survey dummies. In column (3) I include the control variables representing internationalization and market structure, in column (4) the variable that controls for the average profitability of the firms in the sectors, and finally in column (5) the full specification. The coefficient of $sdroa\_1_{s,p}$ is negative and significant in all specifications except than in column (1). In this case the coefficient of $sdroa\_1_{s,p}$ becomes positive, because the volatility of profits and the frequency of innovation are positively correlated across 2 digit sectors and across surveys, and therefore if these dummies are omitted the coefficient of $sdroa\_1_{s,p}$ is biased upwards. The presence of this bias is confirmed by the fact that the increase in the coefficient of $sdroa\_1_{s,p}$ also happens for non entrepreneurial firms (see the last row of table XIII). Similar results are found when I use $fix\_inn_{i,p}$ as dependent variable (second part of the table).

Therefore, for the results presented above to be explained by an endogeneity problem, it should be that some other factor, which varies across three digits sectors, is at the same time negatively correlated with the risky innovation of entrepreneurial firms and positively correlated with the volatility of profits in the sector.

In the two tables below I provide two further robustness checks that control for this hypothesis. In table XIV I include in the estimation 3 digit sector dummies. This implies that the coefficient of $sdroa\_1_s$ is identified only by changes in each sector over time rather than by changes across sectors. The combined presence of 3 digit sector fixed effects and survey fixed effects controls for the impact of any sector specific unobserved variable and for any survey specific effect. Moreover I substitute the control variables $supply_{i,p}, constrained_{i,p}, roa\_avg\_6_{i,p}, \ln(size_{i,p}), age_{i,p}$ and $age_{i,p}^2$ with sector specific variables. For example I substitute $constrained_{i,p}$ with $constrained_{s,p}$, which is the fraction of constrained firms in sector s and survey p. This change takes into account the fact that such variables at the firm level are also possibly endogenous. Table XIV shows that the coefficient of $sdroa\_1_{s,p}$ is very similar, across the different groups, to the coefficient estimated in the regressions that included only 2 digit sector dummies (see table IX). At the bottom of table XIV, I report the estimated coefficient of $sdroa\_1_{s,p}$ for the groups of firms selected according to diversification and to financing constraints.

These results are also broadly consistent with those in the previous tables. Finally, table XV proposes an instrumental variable estimation. The model is similar to the model estimated in the previous table XIV with the only difference that it is estimated as a linear model with instrumental variables, and that its standard errors are not clustered. The choice of using a linear IV estimator is justified by the fact that all the previous regression results change relatively little if I estimate them as linear models rather than as Probit models. The variable $sdroa\_1_{s,p}$ is instrumented using the following variables: $sdroa\_1_{s,p-1}$ and $avgroa\_1_{s,p-1}$, which are the cross sectional volatility and mean of return on assets for the sector s in the previous survey; $sd\_output_{s,p}$ and $sd\_output_{s,p-1}$, which are the standard deviations of the trend deviations of an index of revenues for sector s during the last year of survey p and $p-1$ respectively.[15] These last two instruments are computed using monthly data from the Italian Statistical Institute (ISTAT) for all manufacturing 3 digit sectors. Therefore they are based on a time series of data and on a sample different from the sample of the Mediocredito Surveys. In the context of this IV approach it is not feasible to cluster the standard errors in this regression. Nonetheless standard errors are computed using a robust 2 step procedure, and the estimation of the previous models showed that robust standard errors do not change significantly with or without clustering at the 3 digit sector level. Table XV reports, for brevity, only the estimates of the coefficient of $sdroa\_1_{s,p}$ for all the different regressions. It also reports the $F-statistic$ of the excluded instruments calculated in the first stage and the p-value of the Hansen's J test of overidentifying restrictions. Both statistics show that the validity of the instruments is not rejected across almost all the different specifications. The α_1 coefficient measuring the sensitivity of innovation to uncertainty follows the same pattern observed

[15] Before detrending, the indexes have been deseasonalised.

in the previous tables, even though is generally more noisily estimated. Nonetheless the results still confirm all the prediction of the model. First, the decisions to improve the existing production $r\&d\_t.a.$ and $fix\_t.a.$ are not affected by uncertainty for all firm. Second, the negative effect of uncertainty on the product innovation of entrepreneurial firms increases for less diversified firms, especially after excluding financially constrained firms.[16] Indeed among the less diversified and not financially constrained firms, the effect of uncertainty on product innovation is negative and significant for entrepreneurial firms for both the $r\&d\_inn$ and fix_inn indicators, while is much smaller and not significant for the other firms.

IV Conclusions

This paper studies the effect of entrepreneurial risk on the relationship between uncertainty and innovation. I consider a model of an economy where undiversifiable entrepreneurial risk matters in equilibrium for the investment decisions of entrepreneurial firms. In this context I analyze the implications of this risk for the relationship between uncertainty and risky innovation. I show that an increase in uncertainty adversely affects the investment in risky innovation of entrepreneurial firms, while it does not affect the innovation decisions of risk neutral firms. The predictions of the model are confirmed by the empirical analysis of a sample of small and medium Italian manufacturing firms.

The main message of this paper is that the effect of uncertainty on entrepreneurial innovation is quantitatively significant. The estimation results imply that if the cross sectional volatility of profits increases from 0.078 (the median value) to 0.097 (the 90%

[16] The criterion to identify more diversified firms is a value of $divers_{i,p}$ greater than 0.3 instead of greater than 0.5. This is because for this IV estimation the 0.5 threshold would leave too few observations in the sample and it would not allow to compute robust two step standard errors.

percentile), the probability to do R&D to introduce new products for an entrepreneurial firm decreases from 14.7% to 11.8%. If one believes that the level of uncertainty faced by firms varies significantly in the business cycle, and that entrepreneurial innovation may be a source of growth and positive externalities for the economy, then this finding implies that the effect of entrepreneurial risk on innovation may be an important factor for both business cycle fluctuations and growth.

The second message of the paper relates to the previous literature on entrepreneurial households. Many authors have been focusing on borrowing constraints as an important factor that influences entry in the entrepreneurial sector, the wealth distribution and capital accumulation in the economy (see for example Caggetti and De Nardi, 2006). In contrast, this paper shows that undiversifiable risk is also important to understand the investment decisions of entrepreneurial firms. In particular, it shows that such risk implies that the negative impact of uncertainty on entrepreneurial innovation is strongest in economies with more efficient financial markets and less financially constrained entrepreneurs.

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V Appendix 1

The dynamic investment problem of the entrepreneurial firm is solved with a numerical method. First, I discretise the state space of the state variables w_t and A_t in grids of 100 points and 5 points respectively. Then I formulate an initial guess of $E_t\left[V\left(S_{t+1}, w_{t+1}, A_{t+1}\right)\right]$, and I use it to compute the value functions $V_t^{up}\left(S_t, w_t, A_t\right)$ and $V_t^{noup}\left(S_t, w_t, A_t\right)$. Then I compare the two function and determine the new guess of $V\left(S_t, w_t, A_t\right)$. I iterate again this process until the value function converges. The final outcome is the optimal policy functions of consumption $c_t\left(S_t, w_t, A_t\right)$, capital $k_{t+1}\left(S_t, w_t, A_t\right)$, borrowing $b_{t+1}\left(S_t, w_t, A_t\right)$ and innovation decision $I_t\left(S_t, w_t, A_t\right)$. The dynamic investment problem of the risk neutral firm is solved using a similar procedure.

Figure 1: R&D and the cross sectional dispersion of returns

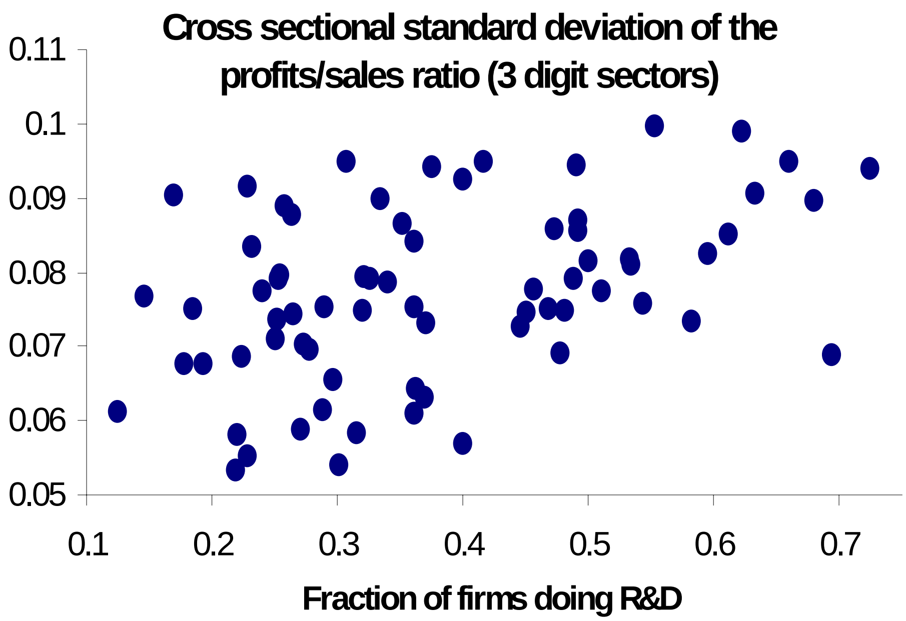

Figure 2: Relative frequency of R&D directed to introduce new products and the cross sectional dispersion of returns

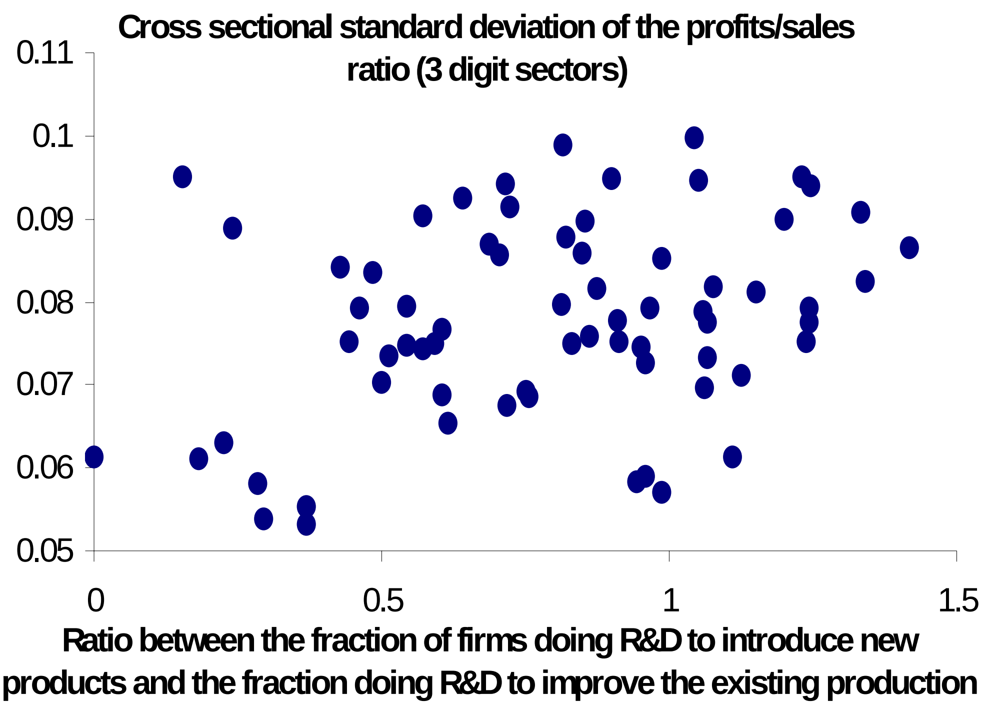

Figure 3: Relative frequency of new fixed investment directed to introduce new products and the cross sectional dispersion of returns

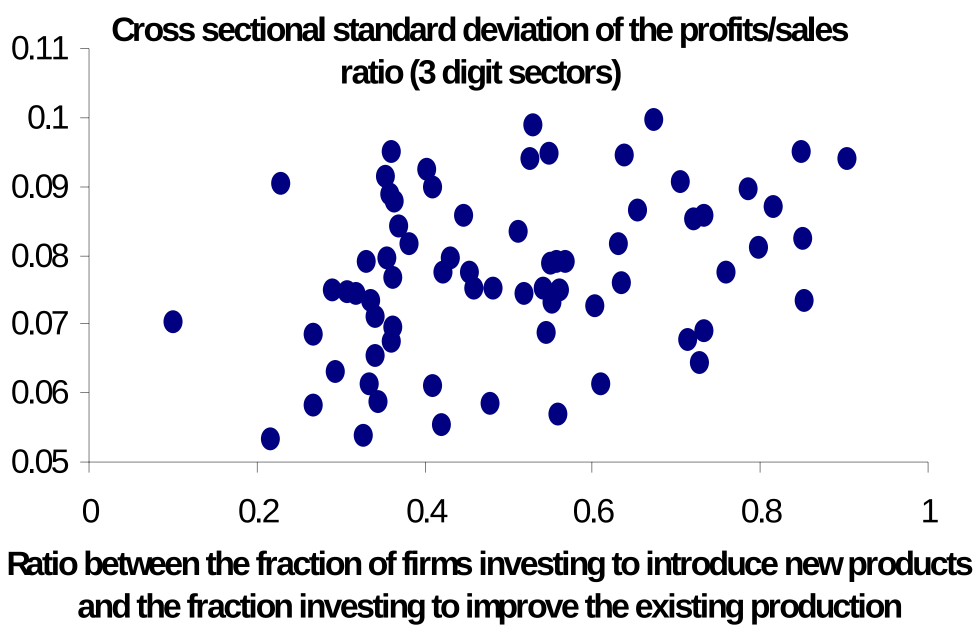

Table I: Calibrated parameters

	Value	Matched moment	Data	Simulations
α	0.865	Average(net income/sales)*	0.136	0.115
δ	0.145	Average depreciation of capital	14.5%	14.5%
ξ	15%	Average frequency of innovation**	14%	14%
$\frac{\theta(S_H)+\theta(S_L)}{2}$	0.05	st. dev (net income/sales)*	0.09	0.10
β^d	0.971	real interest rate	3%	3%
β^e	0.942	% of private equity from entrepreneurial households with concentration $\geq 75\%$	48%	48%
g	0.4	Cost of innovation as a fraction of the value of assets	3.75%	5%

Other benchmark parameters: $\eta = 2$; $\phi = 0.05$; $\overline{A} = 1$; $\underline{A} = 0.61$; $\delta_A \in (0.06 - 0.054)$; $\theta(S_H) - \theta(S_L) = 0.05$, $\rho = 0.8$, $\gamma = 0.4$, $\overline{b} = 0.75$, $\tau = 0.9$

*Statistics computed using the 1989, 1992, 1995 and 1998 Surveys of Consumers Finances, where only entrepreneurs that own and manage a manufacturing company are included, and also excluding as outliers the observations greater than one in absolute value. ** Fraction of entrepreneurial firms that declare to perform R&D in order to introduce new products.

Table II: Investment in fixed capital and innovation, benchmark parameters, risky innovation and technology adoption

	Risky innovation			Technology adoption		
	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)
	Standard deviation of the $net\ profits/sales$ ratio					
Benchmark	.0986	.0889	.1070	.0964	.0882	.1036
Higher uncertainty	.1164	.0975	.1325	.1266	.1064	.1440
Risk neutral firms, benchmark	.1012	.0910	.1105	.1196	.0996	.1367
Risk neutral firms, higher uncertainty	.1196	.0996	.1367	.1272	.1068	.1448
	Return on capital					
Benchmark	2.408%	2.386%	2.430%	4.002%	3.994%	4.009%
Higher uncertainty	2.473%	2.421%	2.525%	4.093%	4.068%	4.118%
Risk neutral firms	2.340%	2.340%	2.340%	3.986%	3.986%	3.986%
	Average capital					
Benchmark	103.2	104.0	102.4	64.4	64.7	64.1
Higher uncertainty	99.1	100.8	97.5	62.7	63.6	61.9
Risk neutral firms	108.7	108.7	108.7	66.0	66.0	66.0
	Frequency of innovation					
Benchmark	13.61%	13.87%	13.35%	13.50%	13.48%	13.52%
Higher uncertainty	13.26%	13.78%	12.73%	13.79%	13.80%	13.67%
Risk neutral firms	14.3%	14.3%	14.3%	13.8%	13.8%	13.8%

Table III: Investment in fixed capital and innovation, comparison between stochastic depreciation and deterministic depreciation of technology (economy with high uncertainty)

	Stochastic depreciation of A_t			Deterministic depreciation of A_t		
	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)
Return on capital	2.473%	2.421%	2.525%	1.890%	1.864%	1.912%
Average capital	99.1	100.8	97.5	83.6	85.3	81.8
Frequency of innovation	13.26%	13.78%	12.73%	16.86%	17.40%	16.32%
Frequency of innovation, risk neutral firms	14.3%	14.3%	14.3%	17.2%	17.2%	17.2%

Table IV: Investment in fixed capital and innovation, different levels of risk aversion

	Benchmark			Higher uncertainty		
	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)	Full sample	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)
	Standard deviation of the $net\ profits/sales$ ratio					
$\eta = 1.1$	.1007	.0905	.1098	.1185	.0992	.1350
$\eta = 2$ (benchmark)	.0986	.0889	.1070	.1164	.0975	.1325
$\eta = 3$	.0961	.0865	.1048	.1141	.0947	.1305
*mixed types**	.1007	.0888	.1112	.1290	.0913	.1579
	Return on capital					
$\eta = 1.1$	2.360%	2.351%	2.370%	2.400%	2.372%	2.427%
$\eta = 2$ (benchmark)	2.408%	2.386%	2.430%	2.473%	2.421%	2.525%
$\eta = 3$	2.463%	2.429%	2.497%	2.555%	2.489%	2.622%
*mixed types**	2.394%	2.375%	2.414%	2.476%	2.408%	2.544%
	Average capital					
$\eta = 1.1$	106.6	107.1	106.2	104.7	105.7	103.7
$\eta = 2$ (benchmark)	103.2	104.0	102.4	99.1	100.8	97.5
$\eta = 3$	98.7	99.7	97.6	93.5	95.8	91.1
*mixed types**	104.3	105.1	103.6	99.7	102.4	97.1
	Frequency of innovation, all entrepreneurs					
$\eta = 1.1$	14.17%	14.24%	14.09%	13.96%	14.25%	13.66%
$\eta = 2$ (benchmark)	13.61%	13.87%	13.35%	13.26%	13.78%	12.73%
$\eta = 3$	12.90%	13.27%	12.54%	11.95%	12.73%	11.17%
*mixed types**	13.77%	13.96%	13.59%	13.45%	14.00%	12.89%
	Frequency of innovation, diversified entrepreneurs ($\frac{w_t}{V_t^M + w_t} \geq 0.5$)					
$\eta = 1.1$	3.15%	3.15%	3.15%	3.33%	3.50%	3.10%
$\eta = 2$ (benchmark)	3.11%	3.07%	3.17%	2.71%	2.95%	2.51%
$\eta = 3$	2.48%	2.26%	2.64%	2.76%	3.25%	2.40%
*mixed types**	9.18%	9.34%	9.02%	8.76%	9.13%	8.41%
	Frequency of innovation, undiversified entrepreneurs ($\frac{w_t}{V_t^M + w_t} < 0.5$)					
$\eta = 1.1$	14.48%	14.52%	14.43%	14.24%	14.47%	14.01%
$\eta = 2$ (benchmark)	13.85%	14.13%	13.57%	13.42%	13.92%	12.92%
$\eta = 3$	13.02%	13.35%	12.69%	12.19%	12.98%	11.39%
*mixed types**	15.31%	15.50%	15.11%	14.86%	15.46%	14.25%

* 50% of the entrepreneurial firms have high volatility of profits ($\theta_L = 0.03; \theta_H = 0.12$) and low risk aversion ($\eta = 1.1$). The remaining 50% of the entrepreneurial firms have low volatility of profits ($\theta_L = 0.06; \theta_H = 0.09$) and high risk aversion ($\eta = 3$).

Table V: Investment in fixed capital and innovation, financially constrained entrepreneurial firms

	No Financing constraints (benchmark, $\tau = 0.9$)		25% financially constrained ($\tau = 0.3$)		50% financially constrained ($\tau = 0$)	
	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)	Low volatility of profits ($S_t = S_L$)	High volatility of profits ($S_t = S_H$)
	Standard deviation of the *net profits/sales* ratio					
Benchmark	.0889	.1070	.0872	.1060	.0898	.1083
Higher uncertainty	.0970	.1318	.0955	.1319	.0980	.1333
	Return on capital					
Benchmark	2.386%	2.430%	2.616%	2.644%	3.023%	3.031%
Higher uncertainty	2.427%	2.540%	2.637%	2.697%	3.040%	3.067%
	Average capital					
Benchmark	104.0	102.4	91.2	90.2	74.5	74.1
Higher uncertainty	100.0	96.8	89.9	87.9	73.8	73.0
	Frequency of innovation					
Benchmark	13.87%	13.35%	12.33%	12.05%	10.67%	10.51%
Higher uncertainty	13.78%	11.73%	12.09%	11.75%	10.61%	10.34%

Table VI: Summary statistics

	Entrepreneurial firms	Other firms
Mean n. employees	45	183
Median n. employees	25	41
Mean age	23	27
Median age	19	21
Mean operative income / total assets	7.4%	6.8%
% of exporting firms	66%	71%
Number of firm-survey observations	4505	9084

Table VII: Share of firms that invest in innovation

	Entrepreneurial firms	Other firms
	r&d	
No *r&d*	69%	59%
$r\&d\_innov = 1$	15%	20%
$r\&d\_t.a = 1$	16%	21%
	New fixed investment	
No new fixed inv.	15%	9%
fix_innov	26%	31%
$fix\_t.a.$	59%	60%

Table VIII: The relationship between risk and innovation

$$y_{i,p} = \alpha_0 + \alpha_1 roa\_stdev\_6_{i,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} + \alpha_4 constrained_{i,p} + \\ + \alpha_5 roa\_avg\_6_{i,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$$

	$y_{i,p} = r\&d\_inn_{i,p}$		$y_{i,p} = r\&d\_t.a_{i,p}$		$y_{i,p} = fix\_inn_{i,p}$		$y_{i,p} = fix\_t.a._{i,p}$	
	entr.	other	entr.	other	entr.	other	entr.	other
α_1	-2.29*	0.03	-0.57	-0.10	-3.21**	-0.95	0.71	-0.51
	(-1.6)	(0.1)	(-0.4)	(-0.1)	(-2.5)	(-1.4)	(0.7)	(-0.8)
α_2	0.47***	0.49***	-0.02	0.25***	0.23**	0.25***	-0.15*	-0.13**
	(3.8)	(6.4)	(-0.1)	(3.8)	(2.5)	(4.1)	(-1.7)	(-2.2)
α_3	-0.18*	-0.16***	0.07	-0.03	-0.01	-0.13***	0.03	0.14***
	(-1.9)	(-3.1)	(0.8)	(-0.7)	(-0.1)	(-2.7)	(0.3)	(3.1)
α_4	0.24*	0.18**	0.07	-0.10	-0.04	0.19***	0.07	-0.13*
	(1.9)	(2.3)	(0.6)	(-1.3)	(-0.4)	(2.7)	(0.6)	(-1.8)
α_5	-0.22	0.58	1.97***	-0.14	1.04	0.67*	0.78	0.34
	(-0.3)	(1.5)	(2.7)	(-0.4)	(1.4)	(1.9)	(1.1)	(1.0)
α_6	0.21***	0.23***	0.16***	0.11***	0.18***	0.14***	-0.01	-.003
	(4.1)	(10.5)	(3.3)	(5.6)	(4.0)	(6.9)	(-0.2)	(-0.1)
α_7	0.003	0.05	-.001	-.004	0.01	0.01	-.005	-.001
	(0.5)	(1.2)	(-0.2)	(-1.2)	(0.8)	(1.3)	(-0.9)	(-0.4)
α_8	-0.00003	-.0001***	.00003	.0001***	-.0001*	-.0001***	.0001*	.0001*
	(-0.6)	(-2.9)	(0.7)	(3.1)	(-1.7)	(-2.7)	(1.8)	(1.8)
n.obs	1344	3811	1338	3811	1342	3813	1342	3815
Pseudo R^2	13.19	11.24	0.04	0.06	0.06	0.04	0.05	0.02

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digits sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $roa\_stdev\_6_{i,p}$: standard deviation of the gross income/assets ratio for firm i in the six years before the survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $roa\_avg\_6_{i.p}$: average gross income/assets ratio for firm i in the six years before the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table IX: The relationship between risk and innovation. Exogenous risk measure

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} + \alpha_4 constrained_{i,p} +$
$+\alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$		$y_{i,p} = r\&d\_t.a_{i,p}$		$y_{i,p} = fix\_inn_{i,p}$		$y_{i,p} = fix\_t.a._{i,p}$	
	entr.	other	entr.	other	entr.	other	entr.	other
α_1	-5.04**	-1.87	3.31	1.16	-4.62**	-1.01	2.16	-0.22
	(-2.3)	(-1.3)	(1.5)	(0.9)	(-2.5)	(-0.8)	(1.2)	(-0.2)
α_2	0.37***	0.52***	.26***	0.32***	0.19***	0.24***	-0.07	-0.11***
	(5.4)	(10.4)	(4.4)	(7.6)	(3.4)	(6.1)	(-1.3)	(-3.0)
α_3	-.24***	-0.15***	0.07	-0.03	-0.10**	-0.15	0.14***	0.17***
	(-4.0)	(-4.0)	(1.3)	(-0.8)	(-2.0)	(-4.4)	(2.9)	(5.5)
α_4	0.06	0.18***	0.042	0.013	0.09	0.18***	-0.04	-0.12***
	(0.9)	(3.6)	(0.6)	(0.3)	(1.5)	(4.0)	(-1.5)	(-2.6)
α_5	-1.62	-0.78	-2.98	-0.09	4.36**	2.40*	-2.13	-0.04
	(-0.7)	(-0.5)	(-1.4)	(-0.1)	(2.2)	(1.8)	(-1.2)	(-0.1)
α_6	.25***	0.24***	.18***	0.13***	0.27***	0.18***	-0.05	-0.05***
	(7.0)	(15.4)	(5.4)	(8.8)	(8.4)	(12.8)	(-1.5)	(-3.3)
α_7	0.003	0.006*	-0.002	-0.002	0.007**	0.006**	-0.01***	-0.004*
	(0.8)	(1.7)	(-0.5)	(-1.0)	(2.0)	(2.2)	(-2.8)	(-1.8)
α_8	-.0001	-.0001***	.0004	.0001***	-.0001**	-.0001***	.0001***	.00001***
	(-1.1)	(-3.2)	(0.6)	(3.2)	(-2.5)	(-3.7)	(3.2)	(3.1)
n.obs	3627	7703	3631	7708	3638	7710	3636	7710
Pseudo R^2	0.11	0.13	0.04	0.06	0.06	0.05	0.04	0.03

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table X: The relationship between risk and innovation. Exogenous risk measure. Financially constrained firms excluded

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa_1_{s,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} + $
$+\alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$		$y_{i,p} = r\&d\_t.a_{i,p}$		$y_{i,p} = fix\_inn_{i,p}$		$y_{i,p} = fix\_t.a._{i,p}$	
	entr.	other	entr.	other	entr.	other	entr.	other
α_1	-7.36***	-1.77	4.44**	0.78	-5.21**	-0.94	2.89	-0.19
	(-3.0)	(-1.1)	(1.9)	(0.6)	(2.5)	(-0.7)	(1.5)	(-0.2)
α_2	0.40***	0.51***	0.30***	0.35***	0.16***	0.25***	-0.05	-0.13***
	(5.2)	(9.3)	(4.4)	(7.5)	(2.6)	(-2.9)	(-1.0)	(-3.2)
α_3	-0.20***	-0.16***	0.08	-.04	-0.10*	-0.13***	0.15***	0.16***
	(-3.2)	(-3.7)	(1.4)	(-1.1)	(-1.8)	(-3.6)	(2.8)	(4.6)
α_5	-0.49	-2.01	-4.16*	0.80	5.56***	1.39	-2.75	0.80
	(-0.2)	(-1.2)	(-1.8)	(0.5)	(2.6)	(1.0)	(-1.4)	(0.6)
α_6	0.25***	0.25***	0.19***	0.13***	0.27***	0.18***	-0.04	-0.04***
	(6.5)	(14.6)	(5.2)	(8.2)	(7.9)	(12.0)	(-1.1)	(-2.7)
α_7	0.001	0.006	-.0002	-0.002	0.006*	0.004	-0.009**	-0.002
	(0.2)	(1.6)	(-0.1)	(-0.8)	(1.6)	(1.4)	(-2.4)	(-1.0)
α_8	-.00003	-.0001***	.00003	.0001***	-.0001**	-.0001***	.0001***	.0001**
	(-0.6)	(-3.0)	(0.7)	(2.8)	(-2.1)	(-2.9)	(2.6)	(2.4)
n.obs	3014	6698	3006	6703	3024	6705	3022	6705
Pseudo R^2	0.12	0.14	0.04	0.06	0.06	0.05	0.04	0.03
Coefficient of $sdroa\_1_s$ estimated for the group of financially constrained firms only								
α_1	4.93	-1.36	-1.74	4.66	-2.26	-0.23	-3.06	-0.81
	(1.0)	(-0.3)	(-0.4)	(1.3)	(-0.5)	(-0.1)	(-0.7)	(-0.2)
n.obs	599	1002	613	997	590	1002	590	1002
Pseudo R^2	0.12	0.13	0.13	0.07	0.07	0.10	0.05	0.06

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table XI: The relationship between risk and innovation. Entrepreneurial firms selected according to the degree of diversification

$$y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} + \alpha_4 constrained_{i,p} + \\ + \alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$$

	$y_{i,p} = r\&d\_inn_{i,p}$			$y_{i,p} = fix\_inn_{i,p}$		
	$divers_{i,p} \leq 0.5$	$divers_{i,p} > 0.5$	$divers_{i,p} > 0.75$	$divers_{i,p} \leq 0.5$	$divers_{i,p} > 0.5$	$divers_{i,p} > 0.75$
α_1	-7.88***	-1.77	3.16	-5.10**	-3.97	0.15
	(-2.7)	(-0.5)	(0.6)	(-2.1)	(-1.3)	(0.1)
α_2	0.40***	0.33***	0.32**	0.26***	0.10	0.24**
	(4.3)	(3.2)	(2.2)	(3.5)	(1.2)	(2.0)
α_3	-0.25***	-0.22**	-0.25*	-0.12*	-0.08	0.07
	(-3.3)	(-2.3)	(-1.7)	(-1.8)	(-1.0)	(0.6)
α_4	0.16*	-0.14	-0.06	0.07	0.12	0.23*
	(1.7)	(-1.1)	(-0.4)	(0.9)	(1.2)	(1.7)
α_5	-0.39	-2.55	-5.01	2.88	6.88**	-1.45
	(-0.14)	(-0.7)	(-1.1)	(1.1)	(2.2)	(-0.4)
α_6	0.24***	0.23***	0.04	0.22***	0.30***	0.18**
	(5.3)	(3.6)	(0.4)	(5.3)	(5.4)	(2.0)
α_7	.002	.003	0.02	.01**	.002	-.00003
	(0.3)	(0.6)	(1.5)	(2.2)	(0.4)	(-0.0)
α_8	-.00004	-.00005	-0.0003*	-.0001**	-.00006	-.00003
	(-0.7)	(-0.8)	(-1.7)	(-2.4)	(-1.1)	(-0.2)
n.obs	1958	1669	783	1954	1679	838
Pseudo R^2	0.11	0.12	0.10	0.06	0.05	0.04

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $divers_{i,p}$ is the average of the ratio between the net financial assets and total assets for firm i in survey p. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table XII: The relationship between risk and innovation, entrepreneurial firms selected according to the degree of diversification. Financially constrained firms excluded

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} +$
$+\alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$			$y_{i,p} = fix\_inn_{i,p}$		
	$divers_{i,p} \leq 0.5$	$divers_{i,p} > 0.5$	$divers_{i,p} > 0.75$	$divers_{i,p} \leq 0.5$	$divers_{i,p} > 0.5$	$divers_{i,p} > 0.75$
α_1	-12.6***	-1.98	2.04	-6.32**	-3.78	-0.001
	(-3.8)	(-0.6)	(0.4)	(-2.3)	(-1.2)	(0.0)
α_2	0.47***	0.33***	0.31**	0.27***	0.03	0.10
	(4.3)	(3.0)	(2.0)	(3.2)	(0.4)	(0.8)
α_3	-0.24***	-0.18*	-0.17	-0.09	-0.11	0.02
	(-2.8)	(-1.8)	(-1.1)	(-1.3)	(-1.3)	(0.1)
α_5	2.15	-3.09	-5.04	4.35	7.90**	-0.04
	(0.7)	(-0.9)	(-1.1)	(1.5)	(2.4)	(-0.0)
α_6	0.25***	0.22***	0.06	0.22***	0.29	0.17*
	(4.9)	(3.3)	(0.5)	(4.8)	(4.9)	(1.7)
α_7	-.0008	.002	0.02	0.01*	.002	-0.002
	(-0.1)	(0.3)	(1.5)	(1.7)	(0.4)	(-0.2)
α_8	-.00002	-.00003	-.0003	-.0001*	-.00005	.00002
	(-0.27)	(-0.5)	(-1.5)	(-1.9)	(-1.0)	(0.2)
n.obs	1581	1397	668	1578	1439	715
Pseudo R^2	0.13	0.12	0.10	0.06	0.06	0.05

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $divers_{i,p}$ is the average of the ratio between the net financial assets and total assets for firm i in survey p. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table XIII: The relationship between risk and innovation. Exogenous risk measure and equation selection

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{i,p} + \alpha_3 supply_{i,p} +$
$+\alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{i,p}) + \alpha_7 age_{i,p} + \alpha_8 age^2_{i,p} + d^{2digits}_{i,p} + d^{survey}_{i,p} + u_{i,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$ (entrepreneurial firms)					$y_{i,p} = fix\_inn_{i,p}$ (entrepreneurial firms)				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
α_1	5.01***	-7.58***	-7.62***	-7.38***	-7.36***	2.79*	-3.21*	-3.19*	-5.18**	-5.21**
	(3.0)	(-3.4)	(-3.4)	(-3.1)	(-3.0)	(1.8)	(-1.7)	(-1.7)	(-2.5)	(2.5)
α_2			0.49***	0.49***	0.40***			0.27***	0.26***	0.16***
			(6.5)	(6.6)	(5.2)			(4.6)	(4.4)	(2.6)
α_3			-0.22***	-0.22***	-0.20***			-0.11**	-0.12**	-0.10*
			(-3.4)	(-3.4)	(-3.2)			(-2.0)	(-2.1)	(-1.8)
α_5				-0.62	-0.49				4.99**	5.56***
				(-0.3)	(-0.2)				(2.4)	(2.6)
α_6					0.25***					0.27***
					(6.5)					(7.9)
α_7					0.001					0.006*
					(0.2)					(1.6)
α_8					-.00003					-.0001**
					(-0.6)					(-2.1)
$d^{2digits}_{i,p}$ and $d^{survey}_{i,p}$	no	yes	yes	yes	yes	no	yes	yes	yes	yes
n.obs	3063	3023	3022	3022	3014	3063	3023	3033	3033	3024
Pseudo R^2	0.003	0.08	0.10	0.10	0.12	0.001	0.03	0.03	0.04	0.06
	$y_{i,p} = r\&d\_inn_{i,p}$ (non entrepreneurial firms)					$y_{i,p} = fix\_inn_{i,p}$ (non entrepreneurial firms)				
α_1	6.12***	-0.90	-1.69	-0.92	-1.77	4.06***	0.25	-0.07	-0.48	-0.95
	(5.9)	(-0.7)	(-1.2)	(-0.6)	(-1.1)	(4.2)	(0.2)	(-0.1)	(-0.4)	(-0.7)

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table XIV: The relationship between risk and innovation. Exogenous risk measure. Fixed effects at the three digit sector level included

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{s,p} + \alpha_3 supply_{s,p} + \alpha_4 constrained_{s,p} + \alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{s,p}) + \alpha_7 age_{s,p} + \alpha_8 age^2_{s,p} + d^{3digits}_s + d^{survey}_p + u_{s,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$		$y_{i,p} = r\&d\_t.a_{i,p}$		$y_{i,p} = fix\_inn_{i,p}$		$y_{i,p} = fix\_t.a._{i,p}$	
	entr.	other	entr.	other	entr.	other	entr.	other
α_1	-5.19**	-1.42	5.04	1.07	-5.13**	-0.26	2.69	-0.19
	(-2.1)	(-0.9)	(1.5)	(0.6)	(-2.3)	(-0.1)	(1.4)	(-0.1)
α_2	0.71	0.74	0.51	0.52**	0.26	0.35	0.15	0.03
	(1.5)	(2.5)	(1.2)	(2.0)	(0.6)	(1.4)	(0.4)	(0.1)
α_3	-0.45	0.20	-0.35	0.12	0.09	0.25	0.27	-0.33
	(-0.9)	(0.7)	(-1.0)	(0.5)	(0.2)	(1.0)	(0.8)	(-1.3)
α_4	-1.04	0.40	0.85	-0.50	0.37	0.63	-0.07	-0.38
	(-1.3)	(0.8)	(1.0)	(-1.1)	(0.4)	(1.3)	(-0.1)	(-0.9)
α_5	1.00	-0.67	-2.92	-1.60	3.74	3.86**	-0.64	-1.86
	(0.3)	(-0.4)	(-1.1)	(-0.9)	(1.3)	(2.1)	(-0.3)	(-1.2)
α_6	0.06	-0.03	0.12	0.21	0.40**	0.08	-0.26	-0.15
	(0.6)	(-0.2)	(0.6)	(1.4)	(2.2)	(0.7)	(-1.4)	(-1.3)
α_7	0.025	0.063**	-0.12*	-0.09***	0.12**	0.03	-0.17	-0.02
	(0.5)	(2.1)	(-1.7)	(-3.5)	(2.3)	(1.1)	(-3.2)	(-0.6)
α_8	-.0001	-.001**	.002	.001***	-.002	-.0005	.003	.0003
	(-0.1)	(-2.3)	(1.7)	(4.0)	(-2.0)	(-1.2)	(3.1)	(0.7)
n.obs	3507	7703	3601	7753	3591	7759	3620	7759
Pseudo R^2	0.095	0.080	0.048	0.040	0.044	0.033	0.047	0.03
Estimate of α_1 for firms selected according to diversification and financing constraints								
$divers_{i,p} \leq 0.5$	-7.06**	-2.10	3.73	1.96	-4.08*	-2.18	-1.90	0.39
	(-2.1)	(-1.2)	(1.1)	(0.9)	(-1.7)	(-1.0)	(-0.8)	(0.25)
$divers_{i,p} > 0.5$	-3.50	-0.06	10.05	-1.64	-5.54	3.27	9.02***	-1.00
	(-0.83)	(-0.0)	(1.5)	(-0.6)	(-1.5)	(1.2)	(2.8)	(-0.4)
$divers_{i,p} \leq 0.5$	-14.01***	-4.09**	3.06	2.81	-5.12	-3.24	-1.05	1.41
and no constrained	(-3.2)	(-2.2)	(1.0)	(1.1)	(-1.5)	(-1.4)	(-0.3)	(0.8)
$divers_{i,p} > 0.5$	1.44	3.06	10.3	-2.20	-1.46	4.47	6.97*	-2.05
and no constrained	(0.3)	(0.9)	(1.5)	(-0.7)	(-0.4)	(1.6)	(1.8)	(-0.8)

All regressions are estimated with a maximum likelihood Probit estimator. I use a Huber/White/sandwich estimator of the variance to correct for heteroskedasticity. Standard errors are clustered at the 3 digit sector level. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $divers_{i,p}$ is the average of the ratio between the net financial assets and total assets for firm i in survey p. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d^{2digits}_{i,p}$ is a series of two digit sector dummy variables, and $d^{survey}_{i,p}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.

Table XV: The relationship between risk and innovation. Exogenous risk measure. Fixed effects at the three digits level and instrumental variable estimation

Regression: $y_{i,p} = \alpha_0 + \alpha_1 sdroa\_1_{s,p} + \alpha_2 export_{s,p} + \alpha_3 supply_{s,p} + \alpha_4 constrained_{s,p}$
$+\alpha_5 avgroa\_1_{s,p} + \alpha_6 \ln(size_{s,p}) + \alpha_7 age_{s,p} + \alpha_8 age^2_{s,p} + d_s^{3digits} + d_p^{survey} + u_{s,p}$

	$y_{i,p} = r\&d\_inn_{i,p}$		$y_{i,p} = r\&d\_t.a_{i,p}$		$y_{i,p} = fix\_inn_{i,p}$		$y_{i,p} = fix\_t.a._{i,p}$	
Estimate of α_1 for firms selected according to diversification and financing constraints								
	entrep.	other	entrep.	other	entrep.	other	entrep.	other
All firms	-8.01	-3.50	4.19	0.36	-11.79	-5.04	6.73	7.44
	(-1.3)	(-0.6)	(0.6)	(0.1)	(-1.47)	(-0.8)	(0.8)	(1.1)
F test (p-value)	7.2(.00)	10.5(.00)	7.2(.00)	10.5(.00)	7.2(.00)	10.5(.00)	7.2(.00)	10.5(.00)
prob. of the J test	0.600	0.812	0.148	0.686	0.601	0.457	0.381	0.363
$divers_{i,p} \leq 0.5$	-11.63*	-13.33*	3.25	8.16	-14.94*	-11.45	7.14	12.05
	(-1.6)	(-1.7)	(0.5)	(1.0)	(-1.7)	(-1.3)	(0.8)	(1.4)
F test (p-value)	6.7(.00)	6.3(.00)	6.7(.00)	6.3(.00)	6.7(.00)	6.3(.00)	6.7(.00)	6.3(.00)
prob. of the J test	0.752	0.965	0.880	0.874	0.215	0.830	0.225	0.643
$divers_{i,p} > 0.3$[1]	1.92	4.69	7.40	-2.63	-4.10	0.36	7.83	3.40
	(0.2)	(0.8)	(0.8)	(-0.4)	(-0.4)	(0.1)	(0.7)	(0.5)
F test (p-value)	3.5(.01)	8.6(.00)	3.5(.00)	8.6(.00)	3.5(.01)	8.6(.00)	3.5(.01)	8.6(.00)
prob. of the J test	0.260	0.523	(0.041)	0.473	0.563	0.927	0.159	0.678
$divers_{i,p} \leq 0.5$	-12.31*	-8.26	-2.59	7.73	-19.55**	-4.89	11.53	7.91
constrained excluded	(-1.7)	(-1.1)	(-0.3)	(0.9)	(-2.0)	(-0.6)	(1.2)	(0.9)
F test (p-value)	5.9(.00)	5.7(.00)	5.9(.00)	5.7(.00)	5.9(.00)	5.7(.00)	5.9(.00)	5.7(.00)
prob. of the J test	0.640	0.845	0.959	0.667	0.241	0.864	0.235	0.823
$divers_{i,p} > 0.3$[1]	3.16	8.02	4.25	2.29	-4.45	3.49	6.65	1.60
constrained excluded	(0.4)	(1.2)	(0.5)	(-0.3)	(-0.4)	(0.5)	(0.6)	(0.2)
F test (p-value)	3.0(.02)	6.8(.00)	3.02(.02)	6.8(.00)	3.0(.02)	6.8(.00)	3.0(.00)	6.8(.00)
prob. of the J test	0.368	0.362	0.066	0.674	0.829	0.959	0.366	0.954

All regressions are estimated with a two-step feasible GMM estimator. Standard errors are robust to arbitrary heteroskedasticity. The variable $sdroa\_1_{s,p}$ is instrumented using $sdroa\_1_{s,p-1}$,$avgroa\_1_{s,p-1}$, $sd\_output_{s,p}$ and $sd\_output_{s,p-1}$. The $F-statistic$ refers to the significance of the excluded instruments calculated in the first stage. The p-value of the Hansen's J test of overidentifying restrictions is also reported. $divers_{i,p}$ is the average of the ratio between the net financial assets and total assets for firm i in survey p. *Significant at the 90% confidence level; **significant at the 95% confidence level; *** significant at the 90% confidence level. $sdroa\_1_{i,s}$: standard deviation of the cross section of the gross income/assets ratio for the firms in the three digit sector s in the most recent years of each survey. $export_{i,p}$: equal to 1 (69% of total) if firm i exports part of its production outside Italy, and is equal to 0 otherwise. $supply_{i,p}$: equal to 1 (44%) if firm i produces 100% of its output based on the order placed by downstream firms. and equal to zero otherwise. $constrained_{i,p}$: equal to one if the firm declares financing constraints (14%), and zero otherwise. $avgroa\_1_{i,s}$: cross sectional mean of the return on assets for sector s in the most recent year of the survey. $size_{i,p}$: number of employees of firm i. $age_{i,p}$: age of the firm (relative to the year of the survey) in years. $d_{i,p}^{3digits}$ is a series of three digit sector dummy variables, and $d_{i,p}^{survey}$ is a series of dummy variables that are equal to 1 if firm i is surveyed in Survey p, and equal to zero otherwise.