R&D profitability: the role of risk and Knightian uncertainty

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IPTS-JRC-EC

December 9, 2014
“...there are known knowns; there are things we know we know. We also
know there are known unknowns; that is to say we know there are some
things we do not know. But there are also unknown unknowns – the ones
we don’t know we don’t know...”

Donald Rumsfeld, US Secretary of Defense, 2002
In this presentation

1. concepts of risk and uncertainty
2. why and how their presence affects economic agents decisions
3. empirical evidence of the impact of risk and uncertainty on firms' returns to R&D investment
   - data and measures of risk and ambiguity
   - regression model
   - results and (participatory) discussion
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   - data and measures of risk and ambiguity

   - regression model

   - results and (participatory) discussion
Risk and uncertainty: the difference

Frank Knight (1921) the first economist to make a distinction

- Risk \(\rightarrow\) corresponds to situations in which all the alternative possibilities [states of nature] are known and the probability of occurrence of each can be accurately measured

- Uncertainty \(\rightarrow\) corresponds to situations in which the possible states of nature and/or the probability of occurrence of each state are not foreseeable (measurable)
Types of uncertainty

**Ontological**

impossible to assign a probability or form a subjective belief distribution of situations not yet known or imaginable

- Sutton’s interpretation:
  “unique events”
Types of uncertainty

**Ontological**

impossible to assign a probability or form a subjective belief distribution of situations not yet known or imaginable

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**Epistemological**

- imperfect/incomplete information
- Ellsberg paradox (1961)

→ ambiguity
Risk and ambiguity on firm’s expected returns

Risk

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<tr>
<th></th>
<th>$x$</th>
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<tr>
<td>$\pi$</td>
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\[
E(\pi) = pu(x) + (1 - p)u(y)
\]

In theory, the impact on investment returns is positive - equity returns risk-premium (ERP) puzzle (Mehra and Prescott 1985; Chen & Epstein 2002)

- the impact on profits?
  - Sutton (2006): ± (efficiency)
  - Cozzi & Giordani (2011): -
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\downarrow
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\[
\pi = E(\pi|x, y) + z\sigma_\pi
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\[
z \sim N(0, 1)
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Risk and ambiguity on firm’s expected returns

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risk premium hypotheses

- **mispricing rationale** explains the lagged impact of R&D (Chan et al 2001)

- **risk-bearing** (Chambers et al. 2002; Pastor and Pietro 2003; Vo 2013)
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**Ambiguity**

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In theory...
## Risk and ambiguity on firm’s expected returns

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- the impact on investment returns is positive
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EU Industrial R&D Investment Scoreboard provides financial data of the top 2000 world R&D investors (2004-2012)
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Data

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- **risk** is proxied by the variance of operating profits (Markowitz, 1952)

- how do we proxy for **ambiguity**?
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- **risk** is proxied by the variance of operating profits (Markowitz, 1952)

- **how do we proxy for ambiguity?**

  - *at country-level* → *Uncertainty Avoidance Index (UAI)* measures the extent to which the members of a culture feel threatened by uncertain or unknown situations (Hofstede, 1980) [rule orientation, employment stability, and stress]
    - Freyman & Thurik (2007)
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  - at firm-level → the absolute deviation between the ‘entrepreneur’s revenue forecast error’ ($\alpha_{it} \equiv OP_{it} - E(OP_{it}|R&D_{it-1}, PhyCap_{it-1})$) and the volatility of market capitalisation, $\theta_i$ (variability in the public opinion of a company’s net worth)
Regression model

For a company $i$ at time $t$,

$$OP_{it} = \beta_0 + \beta_1 OP_{it-1} + \beta_2 \log(R\&D)_{it-1} + \beta_3 \log(PhyCap)_{it-1} + \gamma' x_{it} + \delta_t + S_j + \epsilon_{it}$$

$$x'_{it} = (Risk_i, Amb_{it}, UAI^c)$$

To identify the regression parameters we assume

$$E(\epsilon_{it} | I_{it-1}) = 0$$
<table>
<thead>
<tr>
<th>dep. var.: $OP_{it}$</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<tbody>
<tr>
<td>$OP_{it-1}$</td>
<td>0.875***</td>
<td>0.802***</td>
<td>0.804***</td>
<td>0.804***</td>
<td>0.805***</td>
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<tr>
<td></td>
<td>(0.004)</td>
<td>(0.005)</td>
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<tr>
<td>$R&amp;D$ elasticity</td>
<td>0.067***</td>
<td>0.024**</td>
<td>0.028***</td>
<td>0.039***</td>
<td>0.044***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.012)</td>
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<td>(0.013)</td>
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<tr>
<td>$PhyCap$ elasticity</td>
<td>0.049***</td>
<td>0.029***</td>
<td>0.032***</td>
<td>0.032***</td>
<td>0.035***</td>
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<tr>
<td></td>
<td>(0.010)</td>
<td>(0.009)</td>
<td>(0.010)</td>
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<tr>
<td>$risk_i$</td>
<td>0.338***</td>
<td>0.330***</td>
<td>0.436***</td>
<td>0.428***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.016)</td>
<td>(0.017)</td>
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<tr>
<td>$Amb_{it}$</td>
<td></td>
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<td>-0.024***</td>
<td>-0.024***</td>
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<td></td>
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<td>(0.002)</td>
<td>(0.002)</td>
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<tr>
<td>$UAI$</td>
<td>-0.866**</td>
<td></td>
<td></td>
<td></td>
<td>-0.861**</td>
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<tr>
<td></td>
<td>(0.356)</td>
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<td>(0.362)</td>
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Time dummies: ✓ ✓ ✓ ✓ ✓
Industry dummies: ✓ ✓ ✓ ✓ ✓
- Controlling for size
- Interaction of R&D investment with risk and ambiguity
- Relaxing the identification assumption
- Firm fixed effects
- Market effects
- Alternative measures of risk
To do

- Alternative measure of ambiguity
- Distinction between firm inherent risk and exogenous risk (weighted differently)
- Application to a production function framework
- ...
Conclusions

In line with the risk premium and mispricing hypotheses
→ positive impact of risk on profits (and R&D returns)

In line with the ERP puzzle
→ larger R&D returns due to ‘amplification of risk’
→ but negative impact on profits (routinised behaviour)