Knowledge, Risk and Entrepreneurs' Decisions : Evaluation of R&D investment using Cyclic and Recursive Linear mode

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Central theme

The impact of the entrepreneurial decision on knowledge evolution

- This research highlights the importance of the knowledge evolution across a learning process when a decision maker acts according to his behavior regarding risk.
- Generalisation of M. Yildizoglu [2002] model in terms of the representation of the percentage invested in R&D.
- To be much closer to reality we proposed 2 types of model representing the factor of investment in R&D:

  Cyclic model

  Recurrent model

Plan

1. Introduction
2. Cyclic Policy
   - Two period cycles: a mathematical analysis
   - Graphic Interpretation
   - Four period cycles: A mathematical analysis
3. Recursive policy
   - Recursive increasing policy : Mathematical analysis
   - Graphic interpretation
   - Decreasing recursive policy : Mathematical analysis
   - Graphic Interpretation
4. Conclusion:

Introduction

Nelson & **Winter [1982]:** Learning of firms about their environment does not influence their R&D behavior.

NWFirms : rd : a fraction of gross profits invested on R&D.

$$RD_{NWit} = max\{rd_{min}, rd_{NW}\}\pi_{it}$$

M. Yildizoglü [2002]: Learning is taken into account by GAs.

Genfirm:The fraction of profit dedicated to R&D is coded as a chromosome C_i of length T.

$$rd_{it} = \frac{(C_i)_{10}}{\sum_{j=0}^{T-1} 1 * 2^j} = \frac{(C_i)_{10}}{2^T - 1}$$

$C_i : \{0,1\}^T \mapsto \mathbb{R}$ defined by $(p_0, p_1, p_2, ...p_{T-1}) \mapsto \sum_{j=0}^{T-1} p_j * 2^j$.

GA : a machine-learning technique, based on the evolution of chromosomes or bit strings, that locates good solutions.

Limit:The economic reality is non-mechanical (**R. Langlois & M. Cosgel [1993]**).

M. Yildizoglü [2002], showed the importance of interactions a firm-decision power in R&D and the knowledge by learning. In spite of its power, the application of GA in economic science is undermined by many limitation, of which to our utmost interest in this work is the use of **binary chains** in the representation of coefficients of R&D.

Generalization

We extend the model introduced by M. Yildizoglü [2002] by generalizing $(p_i)_{0 \leq i \leq T-1} \in \{0, 1\}$, by $(p_i)_{0 \leq i \leq T-1} \in [0, 1]$
We used two alternative ways of modeling technical change (cyclic and recursive policy) and analyzing how it changes with the risk profile.

Cyclic Policy:Two period cycles

We write the percentage "rd_{it} as an average weighted by the factor, that is a sort of local weighting "by period" and "by cycle", and that varies according to the variation in entrepreneurial behavior.

If T is even,T=2q, $q \in N^*$.

$$rd_{i,T} = \frac{2p_0 + p_1}{3}.$$

If T is odd,T=2q+1, $q \in N$.

$$rd_{i,T} = \frac{\frac{2(2p_0+p_1)(2^{T-1}-1)}{3} + p_0}{2^T - 1}$$

We see that $rd_{i,2N+1}$ trends toward $rd_{i,2N}$ for the large values of N. This policy presents itself as a first approximation.

Graphic Interpretation : $p_0 < p_1$

2 period cycles; $p_0 < p_1$

- $(\underbrace{p_0, p_1, p_0, p_1, \ldots p_0, p_1, \ldots}_{T-uplet})$.

1. C_1:($p_0 = 0$, $p_1 = \frac{1}{4}$), Risk averse.
2. C_2:($p_0 = \frac{1}{4}$, $p_1 = \frac{1}{2}$), Risk neutral.
3. C_3:($p_0 = \frac{1}{2}$, $p_1 = \frac{3}{4}$), Risk taker.
4. C_4:($p_0 = \frac{3}{4}$, $p_1 = 1$),Risk taker.

$p_0 < p_1$: *Configuration*1

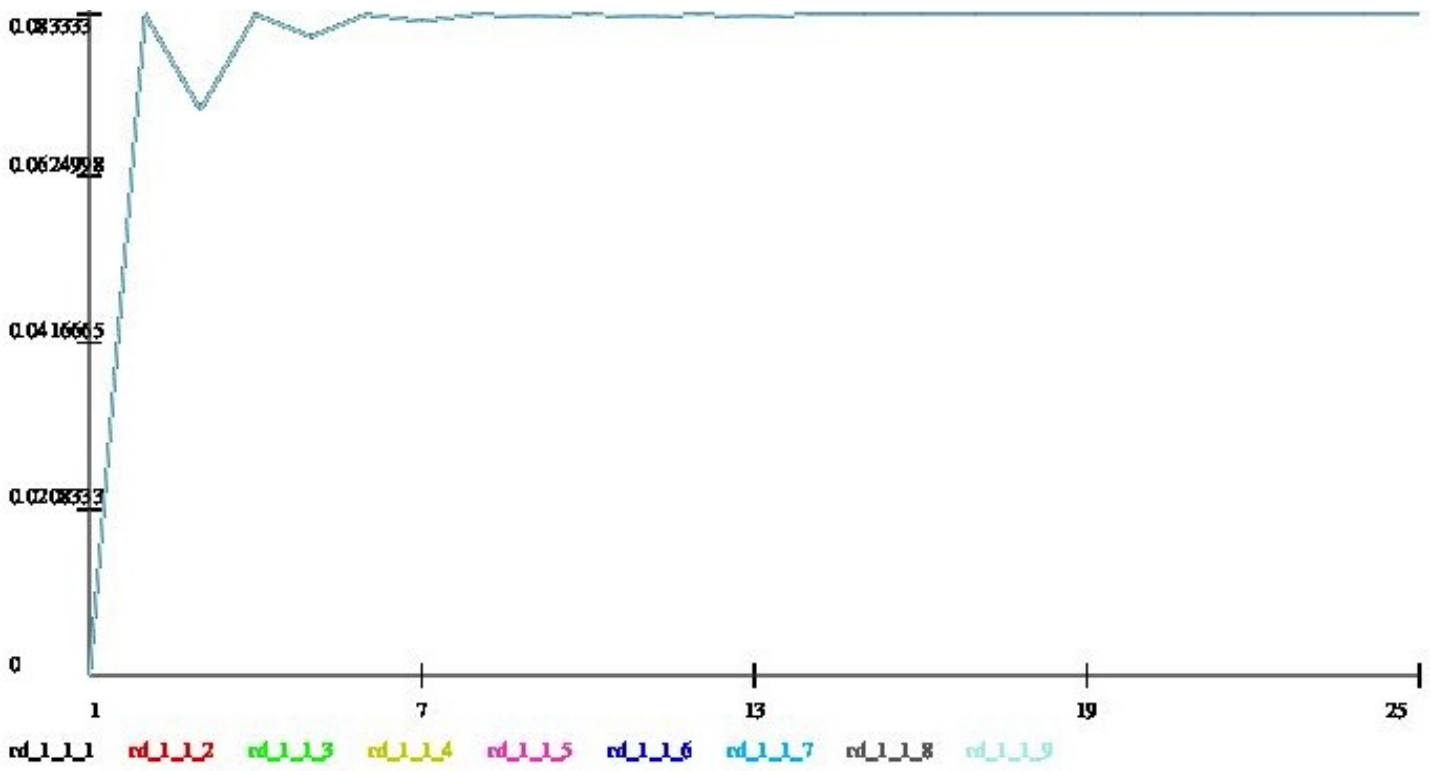

Figure : *Configuration-1-*

$C_1, (p_0, p_1) = (0, \frac{1}{4})$

The figure representing C_1 shows that the factor $rd_{it} \in [0, 0.0833]$.

- What we find interesting is that the maximum value represents the factor rd_{it}, 0.0833., is greatly inferior to 0.25, the decided ercentage during the second period for investment in R&D.
- The graphic interpretation permits us to make the same observation for the **configurations 2, 3** & **4**.

Conclusion

- The decision to invest in R&D depends on the behavior of the decision-maker facing the risk.
- Despite a change in decisional behavior from the first period to the second (from p_0 to p_1), the factor rd_{it} does not respond in an equivalent manner at this change, the gap is, all the same, by 17 %.

Two period cycles (Inverse configurations) : $p_0 > p_1$

The new set of choice will be represented by:

- $"C_1" INV : (p_0 = \frac{1}{4}, p_1 = 0)$
- $"C_2" INV : (p_0 = \frac{1}{2}, p_1 = \frac{1}{4})$
- $"C_3" INV : (p_0 = \frac{3}{4}, p_1 = \frac{1}{2})$
- $"C_4" INV : (p_0 = 1, p_1 = \frac{3}{4})$.

$p_0 > p_1$: $C_! INV$

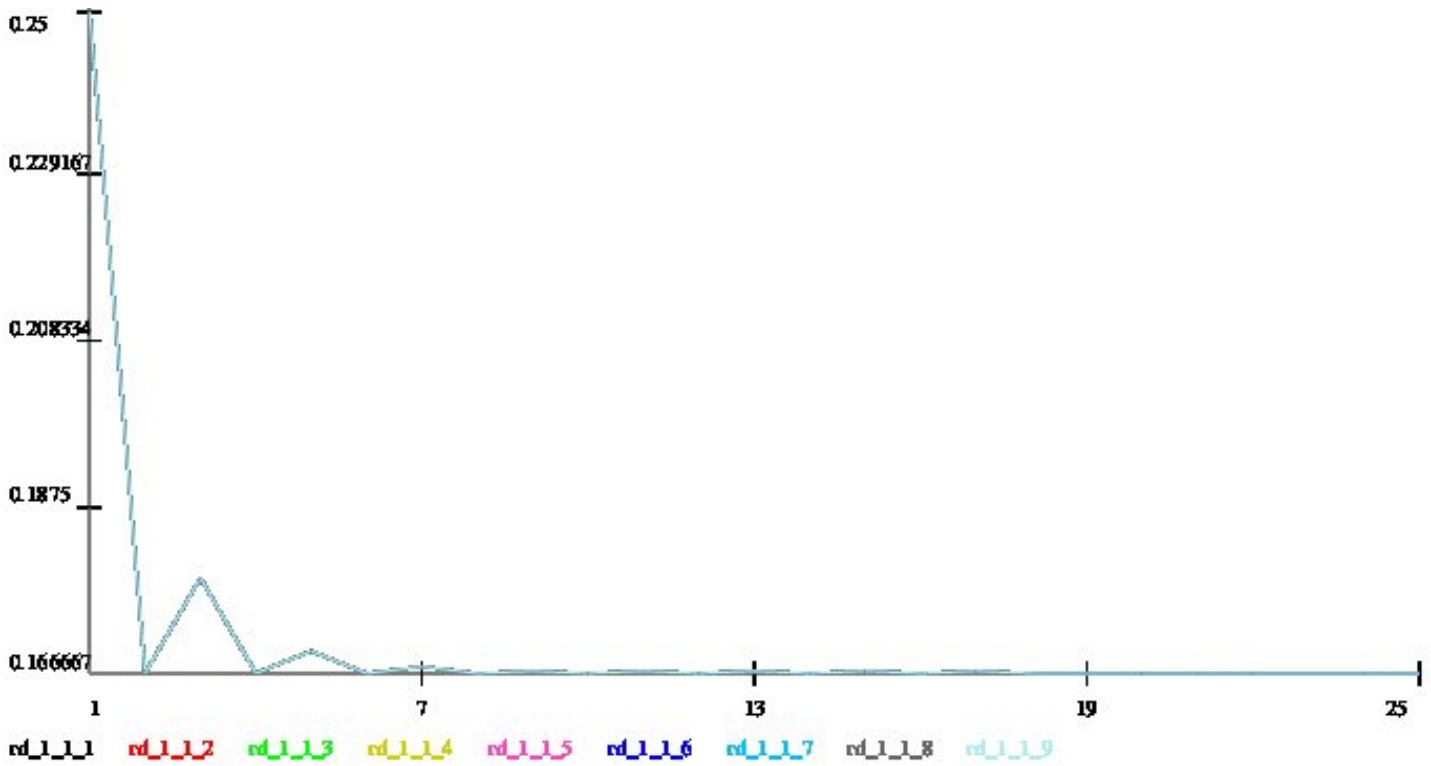

Figure : *Configuration-1INV-*

$rd_{it} \in [0.16, 0.25]$

$C_1 INV, (p_0, p_1) = (\frac{1}{4}, 0)$

The R&D function is as such highly variable and depends strongly on the risk. As a result, the entrepreneur must reflect heavily before choosing a specific proportion.

Conclusion

The initial resulting issues of these experiences allow us to say that "if the entrepreneur decide to adopt a two period cyclic policy, he must choose p_0 and p_1 such as : $p_0 > p_1$". We think that the firm that invests a large part of their profit into R&D at the beginning of a period builds more knowledge, in doing so allowing it to pass the stage of acquisition.

- If the entrepreneur decides to begin the cycle with a modest investment in R&D which increases during the second cycle period. Following this strategy, the knowledge acquired at the beginning of the period isn't important compared to that invested during the second period, and in effect the learning is not of much magnitude.
- The coefficient rd_{it} has permitted us to test the cognitive effect or, more precisely, the evolution of knowledge over a period of time. The company develops thus, via its decisional strategy, a system that permits it to capitalize knowledge and the know-how that were implemented at the beginning of the period.

Four period cycles

This paragraph addresses the idea of a four period cycle.
We found the same results as two period cycles.

Recursive increasing policy

This time we consider a policy $(p_j)_{1 \leq j \leq m}$ that behaves following a recursive result. $p_j = \frac{j}{m}$.

$$rd_{i,T} = \frac{2^{T+1} - 2 - T}{m(2^T - 1)}.$$

The experiment with the percentage $rd_{i,T}$ is effected by the parameter "m",

m=100

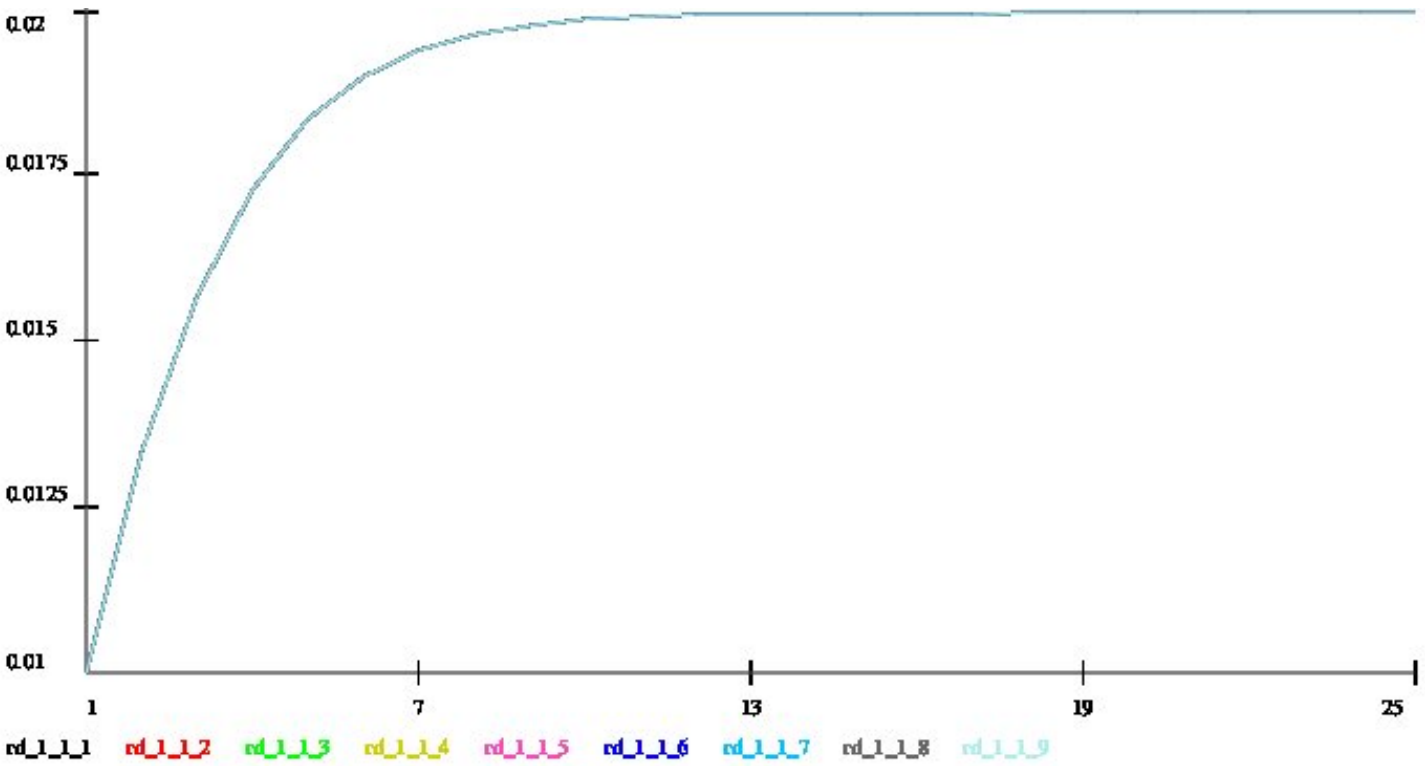

Figure : m=100

Decreasing recursive policy

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e now arrive at the last case study, where the percentage $(p_j)_{1\leq 1-j\leq m}$ behaves as a decreasing recursive sequence.

$$rd_{i,T} = \frac{m-1}{m} + \frac{T}{m(2^T-1)}$$

Interpretation

The firm optimizes the largest part of the R&D investment at the beginning of the period, which allows for the production of knowledge within the company, which lasts throughout its life cycle. This knowledge will evolve by way of the learning effect.

As in the case of the increasing recursive policy, we distinguish three different configurations that depend on values assumed by the parameter "m".

Decreasing recursive policy:

1. If m = 100: $rd_{it} \in [0.99, 1]$ instead of [0.01,0.02]

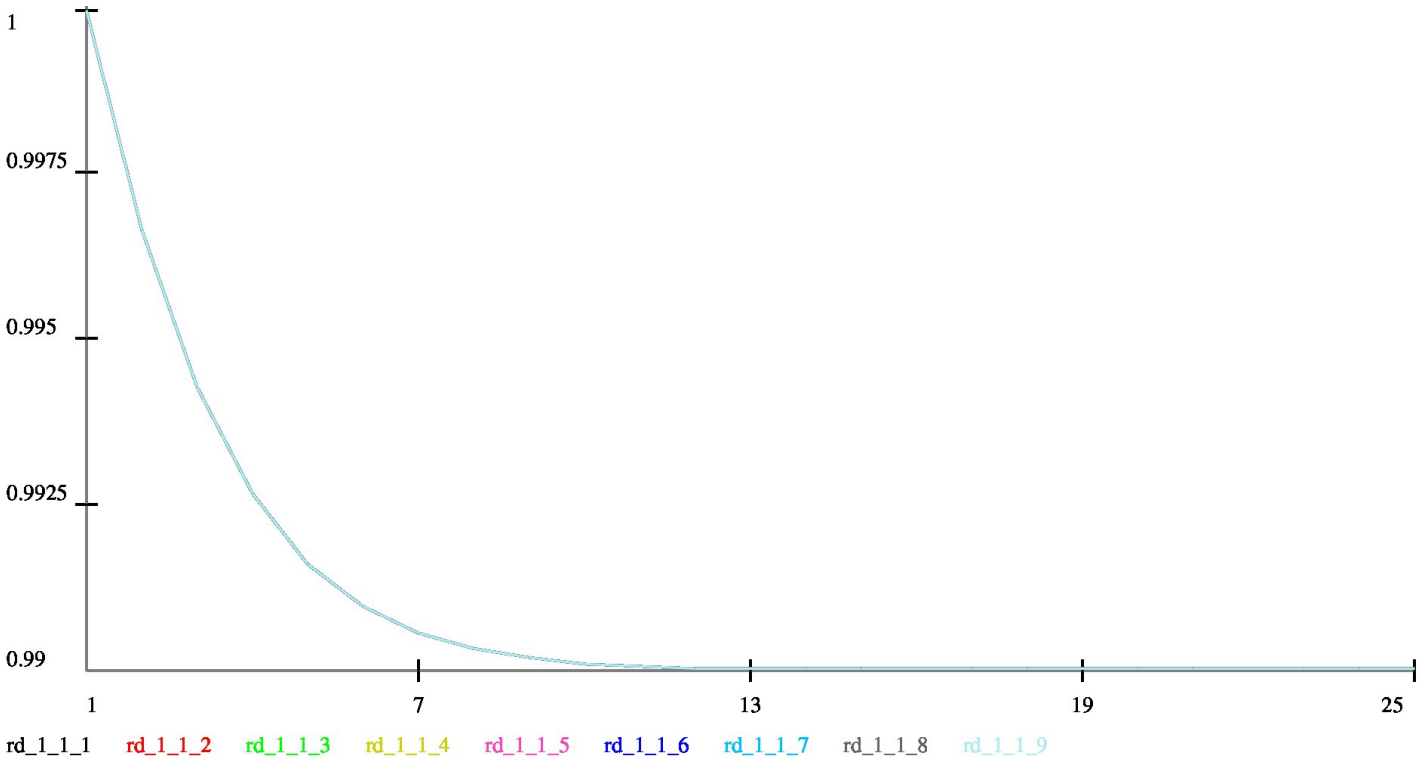

Figure : m=100

Conclusion

With these two models, we have successfully shown the existence of a tight relationship between the decision to invest in R&D and the behavior of the decision-maker who's against risk and the evolution of knowledge within the company.

Thus we have shown that investing in R&D rather proves more effective than increasing the expenditures later, which explains the strong relationship between learning and action, by the definition of C. Argyris [2003][a].

We have also identified the "time" effect that played an important role in the evolution of knowledge.

[a] Page 17.

Limits

- it would be more interesting to go beyond these two particular cases (cyclic and recurring) that we have proposed in order to take a framework of analysis that's more general and more real.
- we can enlarge the model representing the percentage of investment in R&D by constructing it into two parts (stochastic and deterministic part).

References

ADU-BONNAH & K. BAKER E. [2008]
Investment in risky R&D programs in the face of climate incertainty.
Energy Economics (30), 465 – 486.

NELSON R. & WINTER S.G. [1982]
IAn Evolutionary Theory of Economic change
The Belknap Press of Harvard University Press Cambridge, Massachusetts, and London , England.

ADU-BONNAH & K. BAKER E. [2008]
Investment in risky R&D programs in the face of climate incertainty.
Energy Economics (30), 465 – 486.

YILDIZOGL M. [2002]
ICompeting R&D Strategies in an Evolutionary Industry Model
Computational Economics (19), 51 – 65.

VALLÉE T. & YILDIZOGL M.,
Convergence in the Finite Cournot Oligopoly with Social and Individual Learning,
ournal of Economic Behaviour and Organization (30), 72,. 670–690.

Thank you