Market-oriented innovation: When is it profitable ? An abstract agent-based study

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Keywords: agent-based models, innovation, artificial societies

1 Introduction

Agent-based models have been increasingly used to model artificial societies. Many of these models fall into the field of biological sciences and a very important part of them deals with economical problems ([1] [2] [3] and [4]).

Economical, ecological and social environments share as a common feature the fact that the agents operating in these environments spend a large amount of their time trying to maximize some kind of actual or perceived utility, be it related to profit, to food or reproduction or to confort and power. It so happens that many times the improvement of one agent's utility is made at the expense (or causes) the decrease of the other agents utilities. A general concept that is attached to this improvement struggle is the idea of innovation.

In the economy, innovation may be concerned with the identification of new markets, with the development of new products to capture an higher

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market share or with the improvement of production processes to increase profits.

In ecology, innovation concerns better ways to achieve security or food intake or reproduction chance and, in the social realm, all of the above economical and biological drives plus a few other less survival-oriented vanity needs. In all cases, innovation aims at finding strategies to better deal with the surrounding environment and to improve some utility. In any system where at least some agents are trying to innovate, the perfect strategy of today may, with time, become a loosing one. It is the well known "red queen effect": You must run as fast as you can to stay in the same place.

Because money is a "serious matter", it is in the economy field that innovation has been more extensively studied and codified. Three main types of innovations were identified:

(i) *Market innovation* : the identification of new markets and finding out how they are better served or how they may become more receptive to the available products

(ii) *Product innovation* : the identification and development of new products

(iii) *Process innovation* : the identification of better and less expensive production ways or the improvement of internal operations

Although these classification types were developed for economics, it is an easy exercise to find the corresponding notions in the other environments. That also applies to the classification of the *intensity* of the innovations as *radical*, *incremental*, *architectural* and *modular*. An important point to emphasize is that the intensity of the innovation is an agent-dependent concept. An innovation that is radical for one agent might just appear as incremental or of any other type to some other agent [5]

An important concept concerning a system of innovation is the flow of information within the agents of the system and its appropriation in terms of knowledge. However, here, systems of innovation are not assumed. They may only appear as emergent features.

The fact that innovation covers so many different fields and particular settings justifies efforts to develop an abstract model that might have inter field validity.

2 The Model

In the model there are $2N$ agents: N producers and the same number of consumers. Each consumer has a set of needs coded by a string of k bits and each producer has a product coded by a string of k bits . The bit string of a consumer represents what the consumer agent *needs* to receive from the environment and the bit string of a producer is a code for the *products* that he is able to supply. Because no passive actors are assumed in the environment, the environment for each agent is just the set of all the other agents.

In addition to the two bit strings that code for needs and products, each agent has a scalar variable S or C, depending on the agent type (consumer or producer, respectively). The variable S represents the degree of satisfaction of the needs and C represents the amount of some commodity (or Capital) that may be exchanged for the products that are available.

In the economy this role is played by money, but in other contexts it might be protection capacity or power or status.

The dynamics of the model is characterized by *exchange*, *evolution* and *adaptation*. The basic driver of the *exchange dynamics* of the model is the matching between needs and products. At each time step, the mathching between needs and products is made and each agent chooses at random one among the products that better match his needs. The agent that has this product is a potential supplier. That is

$$S_i(t+1) = S_i(t) - ac + \frac{q^*_{ij}}{k} \tag{1}$$

$$C_j(t+1) = C_j(t) - ap + \sum_{j(i)}^{k} \frac{q^*_{ij}}{k} \tag{2}$$

The index $j(i)$ runs over all the agents j that are supplied by the agent i

On receiving a product from the producer i the consumer j increases his Satisfaction (or *energy*) S by $\frac{q^*_{ij}}{k} - ac$. At the same time, the producer j increases his Commodity (or *cash*) C by $\sum_{j(i)}^{k} \frac{q^*_{ij}}{k} - ap$, where ac and ap stand for two constants *costs of living* that are subtracted at each time step from consumers-satisfaction and suppliers-cash, respectively. The variable q^*_{ij} stands for the matching of the producer i that supplies the consumer j.

The above transactions, carried out at a price that only depends on the matching between products and needs, represent the normal *subsistence* operating level of the system.

At each time step needs and products are compared. The producer that supplies each consumer is chosen at random among those with larger matching. When $C_i < 0$ this producer i disappears. When $S_j < 0$ this consumer j is replaced by a new one with random needs string and $S_i = S_0$. As such, a consumer only remains in the field as long as its *energy* S is positive. If it becomes negative, he dies and is replaced by a new random agent. Initially all agents and the replacement agents are endowed with the same initial C_0 and S_0.

Once the number of surviving producers stabilizes there are several possible innovation mechanisms.

- *Market-driven*: the innovation producer finds the consumers that have a matching above a certain threshold and flips the worse bit.
- *Process* innovation corresponds to a price decrease plus half a point of bonus in matching.
- Finally pure *product* the innovation producer finds the consumers that have a matching above a certain threshold and develop a new product string accordingly to their need bits.

There are of course some important features of real markets that are not explicitly included in our abstract codification of the products offered by each agent. For example, products sometimes have some core features that are fixed and some others that are adjustable. Then the agent may supply the same core product to different customers as different offerings. This *market segmentation* technique is particularly important in the service industry [7] [6].

The choice preference in the model being achieved by maximization of the partial matching between products and needs, one may take the point of view that one is dealing only with the core features of products. An explicit coding of core versus adjustable features might be included by keeping some product bits fixed and fuzzifying a few others. However, we believe that the qualitative dynamical features of the model would not be very much affected by this change.

3 Results and Discussion

The model is tested for different values of *ac* and one looks for correlations between the nature of the market and the effectiveness of the innovation process.

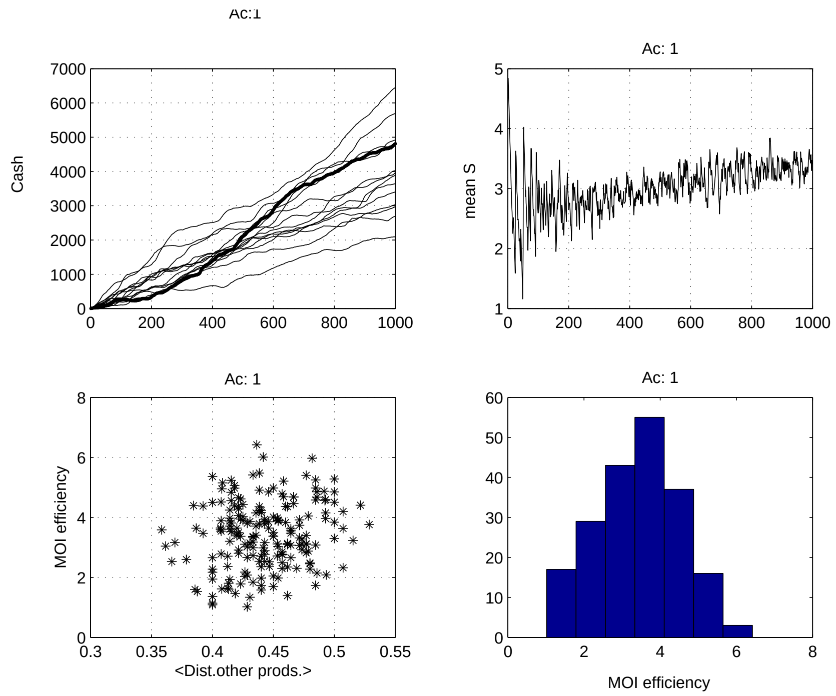

Figure 1: stable environment

3.1 Interpretation

1. Market-oriented innovation is not very efficient in a market with consumer tastes very stable (stable environment in other contexts).

2. Negative correlation of the innovation efficiency with the gains rate before innovation.

3. This type of innovation is profitable in a consumer volatile environment (environment changing rapidly).

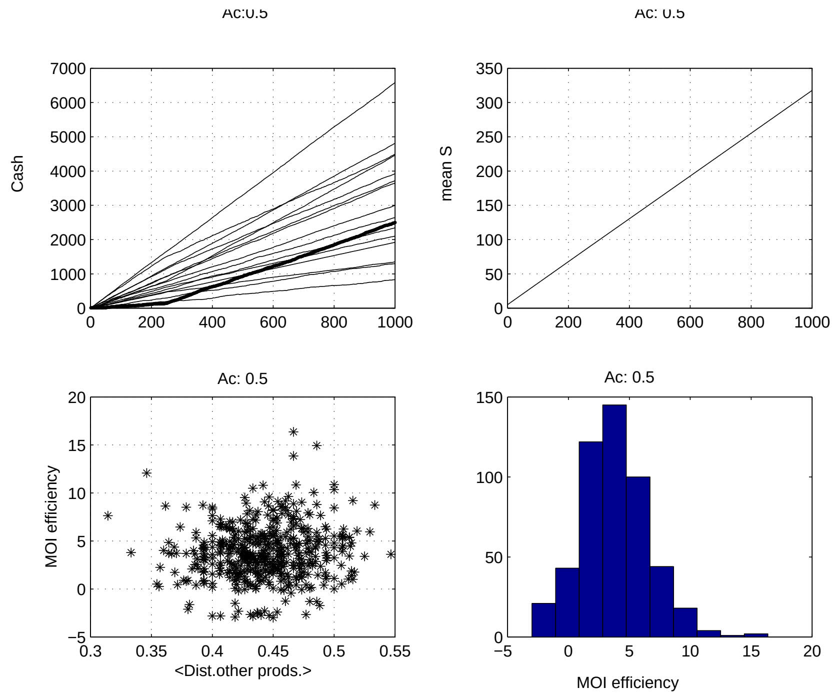

Figure 2: volatile environment

4. Inverse correlation with distance to other products and nearest competitor. But the correlation is strong only in a volatile environment.

3.2 Future developments

The model is also planned to contain a dual mechanism for the *evolution of the needs*On the one hand there will be a general mechanism of evolution of the needs that is not directly dependent on the exchange dynamics. It will be implemented as follows: At each time step (after the exchanges) a k-bit string is chosen at random. Then each agent chooses at random one of his need bits and makes it equal to the corresponding bit of the random string. If it is already equal, nothing happens to this agent. This mechanism that appears here as the working of some external influence (external environment) may, in a more detailed model, be also the result of an endogeneous effect like partial conformity to some fashion. The second mechanism will be one of partial adaptation or conformity with the available products. Again, each

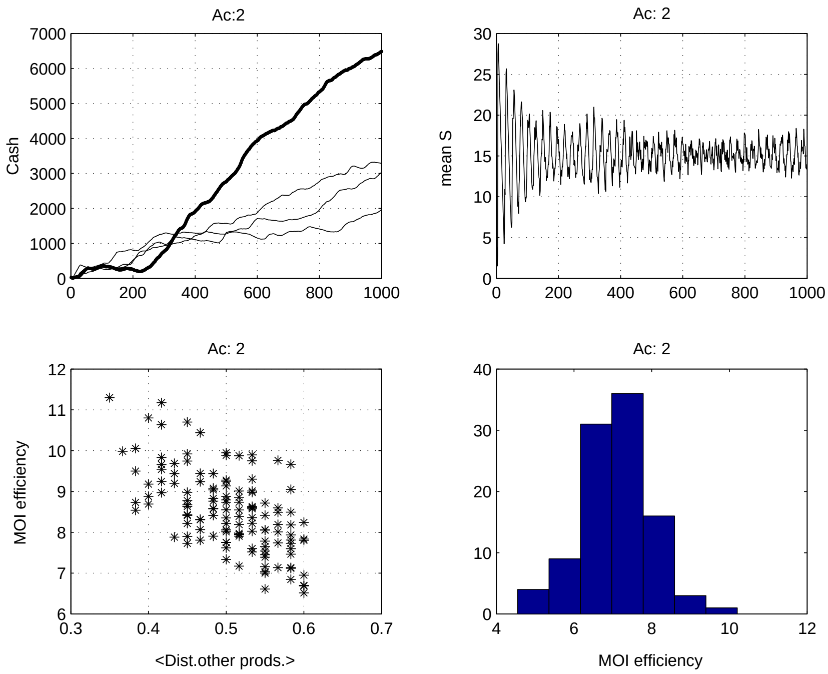

Figure 3: high volatile environment

agent takes one of his need bits at random and changes it to make it equal to the majority of the the same position bit in the products. Here again the majority is computed by counting the innovating agent bits.

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