Economics of the alive one: technology adoption versus acceptance

The case of agricultural biotechnology

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(Project proposal)

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1. Theory / model

1. *Question to be researched:*

My research will try to explain how and why do institutions and individuals affect (and adapt to) the diffusion of a new technology by focusing on the case of agricultural biotechnology. Can political and social institutions delay or wreck an innovation and if so, by which way?

2. *historical / Economic relevance:*

The development of agricultural biotechnology has something of paradoxical. On one hand, recent innovations induced by the control of genetic engineering, particularly transgenesis, have permitted the usage in agriculture on a large scale of processes and products with significant benefits all along the food-processing industry. These promises have led to a fast and heavy adoption. But on the other hand, uncertainty and risks linked to Genetically Modified Organisms (GMOs) spread on a large scale for human health and environment, have provoked a wide and international mobilization movement driven by several colored organisms (NGOs, agricultural unions…). Since a few time, the rate of agricultural biotechnology diffusion have globally slowed down, and their development in Europe have been stopped leading to modifications on agricultural strategies and policies (Brazil and Canada for instance). It is not unreasonable to think this resistance has had a significant effect on the green

biotechnology development, both *directly* by conducting to a revision on adoption strategies by food-processing industry (farmers, retailers, seed companies, food processors), and *indirectly* inducing changes on food and agricultural policies (labelling, identity preservation…).

3. Theoretical relevance:

Technology diffusion is the process by which innovations, be they new products, new processes or new management methods, spread within and across economies (Stoneman, 1986). The idea surrounding technology diffusion theories is this process takes time to be carried out. In this long time, it is commonly assumed and observed that the process can be represented as an S-shaped curve. All formal models attempt to produce this representation form. Four main theoretical approaches were advanced to analyze innovation diffusion phenomenon. The first considers technology diffusion as a reflection of the information and learning process (since adopter knows of the existence of the technology, he adopts). The second is based on a view that diffusion is a reflection of differences between adopters (inducing a distribution of reservation prices and adoption at different times as price of the new technology falls). The third emphasize diffusion as the outcome of an oligopoly game (non-instantaneous adoption can occur even with perfect information and homogeneity of potential users). The leading alternative to these three approaches is the evolutionary theory of diffusion, which represents technology diffusion as a selection and learning process and pay attention to heterogeneity of users (for a survey on evolutionary diffusion, see Metcalfe, 1995).

There are three problems with these approaches. First, all of these are mainly based on successful innovations producing the S-shaped curve; thus, there is a bias on sample selection and failure is analyzed on a, somewhere, idealized success framework. Secondly, they pay attention on the long run diffusion process focusing on innovations with a beginning and an end, without explaining satisfactorily short-term fluctuations and first conditions framing the path of diffusion. What are beginning and end, since innovation interacts with economic and social systems and institutions without any break-time? Finally, linked to what have been said just above, they analyze diffusion in a "potential-user" point of view, without bearing in mind, most of the time, interactions with, and effects on, other agents or institutions.

4. Proposed alternative theoretical solution:

The proposed alternative is to analyze technology diffusion as a building and legitimization process, which can suitably capture interactions between individuals (users or not), the technology and institutions

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integrating and reflecting individual commitments. We will try to draw initial conditions and mechanisms, which affect both individuals and institutions and shape a diffusion path inducing irreversibility. This approach is close to evolutionary diffusion theory, but it differs from it because, from my point of view, the main driver of diffusion is not a learning process and failures on decision adoption cannot be exclusively due to an information problem. Learning process only capture technology characteristics and whether it is useful or not, without any other dimension. When new technology diffuse, being used more and more within economic system, it produces effects beyond its sphere of usage and responsively is affected by agents and institutions in a way quite difficult to analyze. Spillovers are not only technology and knowledge spillovers, and one-way directed.

5. *Theoretical significance of the research:*

It is worth considering this issue for at least three reasons. First of all, the starting point of diffusion phenomenon is crucial by determining the ways technology could follow. And uncertainty, oppositions, contingencies and controversy characterize first usage. Next, this framework allows us taking into account relationships between users, technology and institutions and induced effects on society and environment. And last, this solution should permit us to analyze selection mechanisms not only as a learning and information process but also as a controversial process, which legitimize or not the new technology, depending on a debate driven by opposite utility functions, at different stages and levels.

6. *Historical / Policy significance of the research*

Understanding selection mechanisms induced in diffusion process of new technology (how and why do institutions and individuals affect and adapt to the introduction and diffusion of a new technology?) would provide a tool to facilitate decision-making process in an uncertain and controversial environment. Among others, agricultural and technology policy, or risk management would be better oriented by considering relationships between economic agents, citizens, institutions and environment. In a moving and complex world, understanding the way by which innovation introduces and disturbs economies and agents is a very interesting challenge, could led to a better harmony within human-beings and between humans and nature.

2. Methodology

7. *Research design:*

I intent to use both modelling and critical case study to analyze selection and legitimization process leading to the success or failure of a new technology.

✓ Modelling

The game theoretic framework will help me to formalize interrelations between agents, interested in the use of the technology and those who are reluctant, or do not have utility on its usage. Agents will be characterized by a hedonic utility function that depends on both a direct satisfaction by consumption or usage and an indirect one by response to greater goals (politics, moral or ethics…). In this case, firm profit maximization, is only an intermediate from a biological point of view to utility contentment, and thus biological satisfaction. Repeated games will thus make interact two or more pressure groups, in which individuals have the same utility function, producing different diffusion paths depending on uncertainty level, economic power, positive or negative information shocks, institutional structure, etc… On this framework, we will be able to analyze technology diffusion from the moment it is introduced to the time it is selected and work on stabilized market and institutional environments. This contextualization of diffusion will also make clear that the way it works is not isolated from individuals using technology, markets perturbed by its introduction and institutions regulating the evolution, all of this driven by much more than an information and learning process.

Given the difficulties of measuring such effects and variables, simulations will give us interpretable results comparable to empirical analyzes and case studies. It also leads to some indicators for policy implications.

✓ Critical or limiting case study

To fill the lack of empirical results, some critical case studies will be provided to compare with simulation results. Among others, the case of Bt Corn in Europe is a very workable example because it crystallizes the debate in Europe over agricultural biotechnology shaping the diffusion path of this new technology. Golden rice and hormone growth usage and implications are others. For instance, Golden rice is a variety of rice, which have been

genetically modified to produce a precursor of vitamin A to feed populations in developing countries. But the way this innovation could follow is all but obvious, because of uncertainty on risks. Also because the benefits of manipulating life to feed the world is discussed taking into account dependence of these populations from industrialized countries or global firms, other ways more sustainable to feed them and a lot of other reasons that doesn't make clear whether it will be adopted.

8. Sample:

To assess the rhythm of diffusion of agricultural biotechnology we will use the farmers' adoption rate of genetically modified seeds, approximated by the areas of transgenic crops on total areas sowed. We will also use data on field trials to know the crops could be introduced on markets on few times. The time period will be from 1996, year of the first introduction of such crops for market use, to nowadays.

To contextualize the research, we will use stories of some crops, analyzing their key elements to show how institutions, individuals and technologies interact to produce a diffusion path.

9. Data and data sources:

- Data on areas of transgenic and conventional crops for market and for trials published by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) and over sources (FAO, WTO, USDA, and OECD…).
- Commodity flow (OECD, Eurostat, Agreste, and FAO…).
- Surveys on consumer perception and acceptance of biotechnology.
- Several Private Consultants like Ernst & young for the market structure, venture capital investments, and subsidies…
- Newspapers and interviews for case studies.

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