VERY PRELIMINARY VERSION

Why does Monsanto introduce genetically modified seeds in every country differently?
An inquiry into the worldwide commercialization of Bt Cotton

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Introduction

The biotechnology[1] revolution, initiated in the late 1970's heralded a new paradigm in the creation of new plant varieties by ushering in genetically modified plant varieties or GMVs. Unlike the agricultural revolution of the 1960's, the green revolution, which was initiated and diffused by public laboratories, the worldwide diffusion of GMVs is being led by a handful of firms. Hailed as the "Big 6", Monsanto (USA), Dupont (USA), Dow Agrosciences (USA), Bayer Crop Science (following the acquisition of Aventis Crop Science by Bayer), BASF (Germany) and Sygenta (Switzerland), hold over 76% of the market share of agbiotech products (Agrow Reports, 2002; p27). These firms are present in most of the countries belonging to the WTO (World Trade Organization).

The objective of this paper is to understand the rationality behind the commercialization strategies pursued by the agbiotech firms in the different countries of the world.

Prior to the biotech revolution, a distinct category of organizations, "the plant breeders" (either private firms or public laboratories depending on the country concerned) created new plant varieties and these organizations were often selling seeds as well. With the emergence of biotechnology, knowledge of cellular and molecular biology came to be increasingly used to create new varieties, but this kind of competence was usually found in a biotech firm and not in a seed firm.

A transgenic plant is one that is created by artificial insemination of a gene or genes rather than from natural pollination. The inserted gene or genes may come from another plant or even from other species like bacteria, virus or even an animal. GMVs have been developed to incorporate a variety of desirable characteristics in plants such as providing resistance to diseases, pests and stress; increasing shelf life; containing specific nutrients etc.

An agbiotech firm can therefore be considered as a new technology provider in an upstream market, which has to cooperate with a producer of the final product, a seed firm, in the downstream market, in order to commercialize its innovation. The agbiotech firms furnish

[1] Modern biotechnology pertains to a set of techniques that involve manipulation or change of the genetic patrimony of living organisms. Since the 1980's, modern biotechnology has been integrated in a number of industries such as pharmaceuticals, chemicals, agribusiness, agriculture and environment.

the seed firms with plants exhibiting certain desired genetic characteristics (such as tolerance to herbicides, resistance to insects etc.). Then the seed firm crosses these with selected existing plants, to develop new varieties of plants that are optimal for the agronomic conditions of targeted regions and market segments. In other words, a biotech firm, possessing a plant with a particular trait, cannot sell it unless it is transferred to the "elite varieties" developed by breeders for the different market segments. Furthermore, the upstream biotech firm needs the downstream seed company in order to exploit its distribution channels.

Worldwide, the creation of commercially viable GMVs has emerged through cooperation between agbiotech firms and local seed firms. An agbiotech firm has essentially three strategies to choose from to transfer its technology to a seed firm: licensing, joint ventures or mergers and acquisitions. There have been a number of articles detailing how the structure of the seed industry in America has been changed profoundly by vertical agreements between agbiotech firms and seed firms (Bijman, 2001). However, we are still learning about the strategies of the agbiotech firms outside of North America.

In the above context, in order to understand the rationality behind the commercialization strategies for GMVs pursued by Ag-biotech firms in different parts of the world, we focus on the leading Agbiotech firm namely Monsanto, and genetically modified Cotton or Bt cotton, the only GMV that has been commercialized in North America, South America, Africa, Asia and Australia. Two central research questions are then examined:

- What are the different strategies pursued by Monsanto to commercialize Bt Cotton?
- How can the choice of form of collaboration (licensing, joint ventures or mergers and acquisitions s) of Monsanto in the different countries be explained?

In order to answer the above questions, two types of methods are pursued. First, a literature survey is conducted, including articles from the economics stream as well as science journals and internet texts. The different strategies pursued by Monsanto to commercialize GMVs in the different countries are identified. Second, a game theoretic model of technology transfer between an agbiotech firm and a seed firm is formulated and resolved. The Nash equilibrium of this game or the determinants of each form of collaboration is identified as the function of the technological competence of the seed firm or the entity created by a joint venture or merger, and the market share of the seed firm. Finally, there is a discussion on the extent to which the predictions of the model corroborates reality.

The paper is organized as follows. Section 1 briefly outlines the history of Monsanto, the details of Bt cotton and the different strategies pursued to commercialize cotton in the different parts of the world. Section 2 presents the model. Section 3 discusses the extent to which the model corroborates reality. Section 4 concludes.

1 Monsanto and Bt Cotton

1.1 Monsanto: The company[2]

Monsanto was founded in St. Louis, USA in 1901 by John Francis Queeny and their first product was saccharin, which was later sold to the Coca Cola Company. By the beginning of the 1960's, they were manufacturing a variety of chemicals and plastics. During the 1960's, Monsanto diversified into pharmaceuticals and food additives, and agricultural products. In 1976, they launched a herbicide called "Roundup", which went on to become an international block-buster. The gamut of Roundup herbicides created by Monsanto contain a chemical called "glyphosate" which acts as a broad spectrum, non-selective herbicide. It is currently sold in 130 countries on about 50 different cultures, and contributes to about 1/6 of its annual revenues. It is not only used in agriculture, but also in home gardens, by city planners and even conservationists.

Monsanto is acclaimed for its vision and its willingness to take risks to be at the frontiers of innovation. In 1980, it was the first agrochemical company to declare its intention to become a world class molecular biology company and it is at this time that it formed its "Corporate Molecular Biology Group". The first ever genetic modification of a plant cell was performed by Monsanto scientists in 1985 and genetically modified petunias and tobacco was created in their laboratories. From this time they began to work towards producing genetically modified plants for commercial sale.

Monsanto's first biotechnology product was in 1994 recombinant Bovine Growth Hormone (rBGH) or Posilac or BST, which increases the production of milk in cows. This was commercialized on US dairy farms. In 1995 Bollgard insect protected cotton was approved in the USA. In 1996 the US approved Roundup Ready soybean, cotton, canola and corn. Roundup being a non-selective herbicide kills all the bad weeds, but it also spoils some of the main plant, which is also the case with most herbicides. In response to this problem, Monsanto created a series of "Roundup Ready" plant varieties, resistant to their herbicide Roundup unlike a conventional plant. This leads to both cost-saving for farmers in terms of pesticide usage and less environmental damage. The EU and Japan accorded the right to

[2] The general information on Monsanto has been compiled from www.Monsanto.com, www.lightparty.com/health/historyofmonsanto.html

import these GMVs. Monsanto sells its herbicide and its herbicide resistant plant varieties as a package.

Monsanto is also a company that has been greatly criticized in the past for having introduced products deleterious to health. It has manufactured saccharin, a carcinogenic artificial sweetener; polychlorinated biphenyls (PCB's) that cause birth defects; its herbicides were used in "Agent Orange" a defoliant used by the US military in Vietnam that caused horrible fetal deformities. There is still a controversy on whether BST is good for the health of cows and whether there are any long term ill effects from drinking milk produced by cows given Posilac. GMVs have not escaped speculation either.

Initially Monsanto, licensed out "genetic traits" to seed firms. It was felt that this would be the mode of integration of diffusion of GM seeds within the market for many years to come. However, such a vision was overruled in the second half of the 1990's, when it launched a spate of mergers and acquisitions in the U.S. crop seed sector, buying out major companies like "American Cynamid", "Agracetus", "Asgrow", "Calgene", "DeKalb", "Holden's Foundations Seeds". It bought out many of these firms at very high prices, far greater than their sales revenue at the time of acquisition (Jos Bijman, March 2001) (J. Chataway and J. . Tait , 2000). Most of these seed companies were leaders in the corn and soybean seed markets, for which the first biotech trait were developed. However, the acquisitions of seed companies did not stop Monsanto from further licensing out of their GM trait to independent seed companies such as Pioneer and Golden Harvest.

1.2 The worldwide commercialization of Bt Cotton

Bt cotton

In 1911 in the province of Thuringia, in Germany, a scientist discovered that a commonly occurring bacteria of the region *Bacillus Thuringensis* could act as an insecticide against the local "flour moth"[3]. This led to the commercialization of an insecticide using this bacteria in France in 1938 and in the USA during the 1950's. Subsequent generations of the product came into form of a bacterial spray.

Around 1982 scientists in Monsanto succeeded in isolating the genes responsible for the production of the toxin in the bacteria. Later on they managed to insert the gene in cotton plants to create Bt cotton. Bt cotton has the property of being resistant to the family of insects called "Bollworms" which cause losses that runs into millions of dollars worldwide every year. Monsanto has also bought out Bt cotton varieties that are resistant to Roundup. Thus,

[3] http://helios.bto.du.ac.uk/bto/microbes/bt.htm

farmers are offered a package of herbicide and herbicide resistant Bt cotton. This permits them to prevent losses from pests of the bollworm variety and also lowers their herbicide costs.

As with other GMVs, with respect to Bt cotton also there are two kinds of concerns[4]. First, the bollworm pest can develop resistance to the Bt toxin in genetically modified cotton. There are NGOs in different parts of the world who have noted that several species of insect pests have developed resistance to Bt proteins. Good "resistance management" techniques are proposed to combat this possibility such as planting of non-Bt cotton around Bt cotton called the "refuge area" that can accommodate pests! Second, the Bt protein or toxin used to kill the bollworm can enter the food chain through cotton oil and oil cake used to feed cattle. The jury is still out on the verdict.

Commercialization of Bt cotton

The story of the commercialization of Bt cotton is the story of friendship between Monsanto and Delta & Pineland. The firm Delta & Pineland proudly claims on its website that it has the world's largest running private breeding program. From 1988 onwards, it began to scout for the best transgenic cotton varieties. In 1993, Delta & Pineland signed an exclusive agreement with Monsanto to commercialize the transgenic varieties created through their collaboration all over the world except in Australia and India (Pray et al., 2001). Delta & Pineland was to be acquired by Monsanto but this didn't happen because it was overruled by the anti-trust authorities in 1998.

Bt cotton in the USA (introduced in 1996)

=====*to be completed*=========== Delta & Pineland creates the cotton seed using the genetic trait furnished by Monsanto under the exclusive license.

Bt cotton in Mexico (introduced in 1996)

Transgenic cotton was introduced in Mexico in the same year as in the United States, due to its geographical proximity. It was the same strain as the one created for the US market and its distribution is assured by the subsidiary of Delta & Pineland in Mexico. Farmers have to sign a contract not to use the transgenic cotton seeds for a second period, as well as a number of clauses such as ginning the cotton at specified mills. These measures assure an "optimal

[4] www.libertyindia.org/policy_reports/bt_cotton_info_march2002.htm

resistance management" to prevent the pests from developing resistance while safeguarding the intellectual property of Monsanto. The commitment to such contracts is monitored by inspectors from who regularly visit the fields (Traxler et al. 2004).

Bt cotton in Australia (introduced in 1997)

The national laboratory CSIRO of Australia licensed the genetic trait corresponding to the Bt cotton from Monsanto and created its own variety of Bt cotton for the Australian farmers called INGARD. The Bt cotton seeds are distributed in Australia both by CSIRO and the Australian subsidiary of Delta & Pineland.

Bt cotton in China (introduced in 1997)

=====to be completed===========All details can be found in a series of excellent articles by Carl Pray.

Bt cotton in South Africa (introduced in 1997)

=====to be completed=========== Delta & Pineland creates the cotton seed using the genetic trait furnished by Monsanto and there is another South African company.

Bt cotton in Argentina (introduced in 1998)

Monsanto created a joint venture with Deta & Pineland and Ciagro called Mandiyu. Farmers buying transgenic cotton seeds have to sign a contract promising not to use the seed for a second period as in Mexico (Qaim M. et de Janvry, 2003).

Bt cotton in Indonesia (introduced in 2000)

=====to be completed===========

Bt cotton in India (introduced in 2002)

Monsanto present since 1949 in India, approached the Indian Government during the early 1990's to negotiate the commercialization of Bt cotton. However, this was not successful. In 1998, it formed a joint venture with Maharashtra Hybrid Seeds Company Ltd or Mahyco, the biggest cotton seed producer in India. The joint venture is called Mahyco Monsanto Biotech company or MMB and currently the two partners have a 50-50 equity stake in it.

In 1995, the Department of Biotechnology of the Ministry of Science and Technology authorized Mahyco to import 100 grams of Bt cotton. In 1996 this was crossed with the local varieties. Six years later in 2002, they were granted authorization to sell Bt cotton seeds on the commercial markets.

2 The Model

Consider two firms, an agbiotech firm and a seed cum plant breeder firm. Let the market value of a conventional seed be π_c and the market for a GMV be given by π_g in the country concerned. It is assumed that the demand for seeds is satisfied by seed firms which are local monopolies. Let the market distribution network of the seed firm be such that it captures a share p_m of the total national market value, with $p_m \in (0,1)$. Then p_m is considered as the indicator of the market competence of the seed firm and its earning in pre-game period are $p_m.\pi_c$.

The agbiotech firm has three options to commercialize the GMV. It can offer a license to the seed firm for a fixed price *L*. It can also propose a joint venture in which it offers a proportion α of the returns to the seed firm. Finally, it can bid to acquire the seed firm for a sum *M.* We assume that the cost of creating a subsidiary is too high to make it profitable, in order to focus on *collaboration* strategies. But this feature can be easily integrated and does not change the results of the model.

Consider a sequential game in which the agbiotech makes the first move, by offering a license or a joint venture or an acquisition bid to the seed firm. The seed firm can accept or refuse. The transaction is carried out only if the seed firm accepts. The agbiotech firm also has the option of not initiating any form of commercialization of the GMV.

When the agbiotech firm offers a license to the seed firm, the seed firm learns about the technology of GMVs. Let its enhanced technological competence be given by p_t, indicating the probability with which it can create a GMV. In this case the payoff from the technology transaction is *L* to the agbiotech firm and $p_t.p_m.\pi_g - L$ to the seed firm.

Whenever the agbiotech firm offers a joint venture or a merger, it shares all its information with the seed firm. In this case, let the technological competence of the new entity be given by $\hat{p}_t$, representing the probability of successfully creating a GMV appropriate for the local agronomic conditions.

The technological competence after a license p_t can be greater or less than that achieved after a joint venture or a merger $\hat{p}_t$. This is because it is totally dependent on the learning capacity of the seed firm and any possible help it can get from the local public laboratories to create the appropriate plant variety once the license is obtained.

In the case of the joint venture the seed firm and the agbiotech firm share the returns in the ratio of α to $(1-\alpha)$. Thus, in this case, the payoffs to the agbiotech firm and the seed firm are respectively $(1-\alpha).\hat{p}_t.p_m.\pi_g$ and $\alpha.\hat{p}_t.p_m.\pi_g$. In the case of a merger, the technological competence of the new entity is the same as under a joint venture, $\hat{p}_t$, with the price tag of *M* for the agbiotech firm. Thus, the payoffs in this case to the agbiotech firm and the seed firm are respectively $\hat{p}_t.p_m.\pi_g - M$ and *M*.

In case the negotiations do not succeed, i.e. the seed firm refuses the offer, let the payoffs to the agbiotech firm and the seed firm be (l_a, l_s) in the case of license; (j_a, j_s) in the case of a joint venture and (m_a, m_s) in the case of an acquisition.

How are the negotiation values *L*, α, and *M* decided? We solve for them using the simplest game theoretic concept, namely the Nash Bargaining solution. For each player, we compute the difference between what would be obtained if the negotiation fails (i.e. the alternative payoffs) is subtracted from what would be obtained if the negotiation is successful. Let us call this term the net gain from the negotiation. Then the product of the net gain of each of the players is maximized over the variable to be negotiated.

For instance the value of the license *L* is given by the solution to the following problem:

$$\underset{\{L\}}{Max}\left((L-l_a).(p_t.p_m.\pi_g - L - l_s)\right).$$

Then according to the Nash bargaining solution at equilibrium the negotiation variables associated with the agbiotech firm namely *L*, $\left(1-\alpha\right)$, and *M* are as follows:

$$L = \frac{p_t.p_m.\pi_g - l_s + l_a}{2}\ ;\ (1-\alpha) = \frac{\hat{p}_t.p_m.\pi_g - j_s + j_a}{2.\hat{\hat{p}}.p_m.\pi_g}\ ;\ M = \frac{\hat{p}_t.p_m.\pi_g + m_s - m_a}{2}$$

This gives rise to the following payoff matrix where the first term represents the payoff to the agbiotech firm and the second represents the payoff to the seed firm.

		Seed firm		
		License	Joint venture	Merger
Agbiotech firm	License	$\frac{p_t \cdot p_m . \pi_g - l_s + l_a}{2}$ $\frac{p_t \cdot p_m . \pi_g + l_s - l_a}{2}$	(0, 0)	(0, 0)
	Joint venture	(0, 0)	$\frac{\hat{p}_t \cdot p_m . \pi_g - j_s + j_a}{2}$ $\frac{\hat{p}_t \cdot p_m . \pi_g + j_s - j_a}{2}$	(0, 0)
	Merger	(0, 0)	(0, 0)	$\frac{\hat{p}_t \cdot p_m . \pi_g - m_s + m_a}{2}$ $\frac{\hat{p}_t \cdot p_m . \pi_g + m_s - m_a}{2}$

This leads to our first result.

Proposition 1:

(i) *An agbiotech firm will never enter a country unless the market value of GMV is high enough, the market share of a seed company is high enough and the technological competence ensuing is high enough.*

(ii) *A seed firm will never refuse an offer.*

(iii) *In any country, an agbiotech firm has an incentive to initiate any form of collaboration with the seed firm with the greatest market share.*

(iv) *If the alternative payoffs are the same in all forms of collaboration, the returns to an agbiotech is the same from a merger and a joint venture. The choice between either of these two forms and a license depends only on the technological competence associated with them.*

The inferences can be derived easily.

(ii) An agbiotech firm will initiate a license if $p_t.p_m.\pi_g > l_a + l_s$. This can be likened to the "efficiency requirement" of a technology transaction. A license is useful only if it can generate revenue to cover the opportunity costs of the two players. Clearly, the above inequality will not hold for low values of p_t or p_m or π_g. Hence, the inference. It can be similarly proved for a joint venture and a merger.

(ii) We will show this in the case of a license. The results for the other types of transactions follow similarly. An agbiotech will make an offer of a license only if:

$$\frac{p_t.p_m.\pi_g - l_s + l_a}{2} > l_a$$

Adding l_s on both sides of the above equation, we can easily show that:

$$\frac{p_t.p_m.\pi_g - l_s + l_a}{2} > l_a \Leftrightarrow \frac{p_t.p_m.\pi_g - l_a + l_s}{2} > l_s.$$

The latter equation indicates that for the seed firm the payoffs from accepting the license are greater than from refusing it and so it will accept the license.

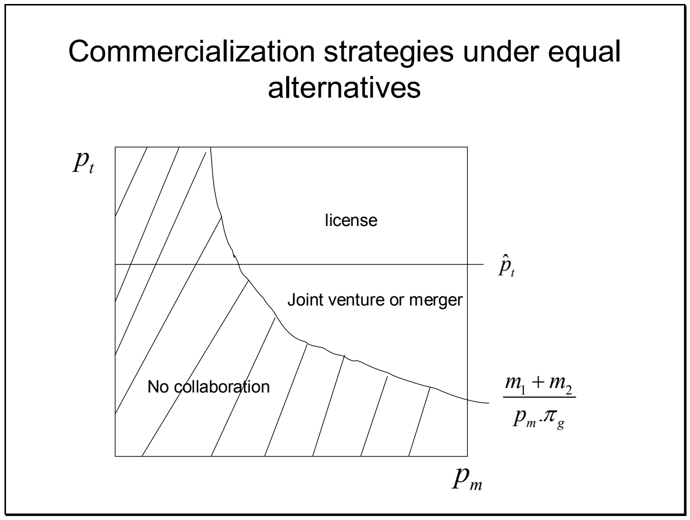
Similarly, in a joint venture and a merger, whenever it is in the interest of the agbiotech firm to initiate a collaboration, it is also in the interest of the seed firm to accept it.

(iii) In any form of collaboration the payoff to an agbiotech firm is an increasing function of p_m and hence increases with the market share of the seed firm.

(v) If $l_a = j_a = m_a$ and $l_s = j_s = m_s$, an agbiotech firm will choose licensing only if $p_t > \hat{p}_t$. This means if the local seed firm can learn faster from a license than it is possible for the new entity created through a joint venture or merger, then it is in the interest of the agbiotech firm to license. In other words, whenever the technological competence of a developing country is high enough, it is in the interest of the Western agbiotech firm to just license out its innovation rather than enter the country.

These results are summarized in figure 1.

Figure 1



However it is unlikely that the alternative payoffs are the same in all the cases.

Whenever there is a license, there is a transfer of "codified knowledge" about the technology in the form of a license, that usually includes information about the technology. Whenever there is a joint venture, there is a sharing of both "codified and tacit knowledge" between the agbiotech firm and the seed firm. Therefore, we assume that if a seed firm refuses offers of a license or joint venture, then the agbiotech firm gets a value *V*, which is equivalent to the monetary value of its knowledge, say royalties on its patents in its home country. The seed firm, on the other hand, falls back on its revenue from conventional seeds $p_m.\pi_c$.

In the case of an acquisition, its an aggressive proposition by an agbiotech. In this case, it is likely that a seed firm is under the threat that if it is not bought out, there is the danger that the agbiotech will enter it anyway. Let us suppose, that if the agbiotech firm enters the market with a variety created in its home country (which may or may not be suitable for the targeted country), given the brand loyalty β to the conventional seed, it will be able to capture a fraction $(1-\beta)$ of the market for the GMV. In other words, if the agbiotech tries to create and commercialize the GMV, its expected payoff is $(1-\beta).p_m.\pi_g$. This leaves the seed firm, $\beta.p_m.\pi_c$ of the conventional seed market, when it refuses the offer of being bought out by an agbiotech firm.

We can one more assumption: $V < \pi_c < \pi_g$. The second inequality is more important than the first and both are realistic.

Under this revised structure we can some additional results.

Proposition 2:

(i) *Whenever the technological competence of the seed firm is higher under a joint venture as compared to under a license, it will be preferred to a license and vice versa.*

(ii) *Whenever the technological competence of the seed firm is higher under a joint venture as compared to under a license, for high values of market competence, a merger will dominate over a joint venture..*

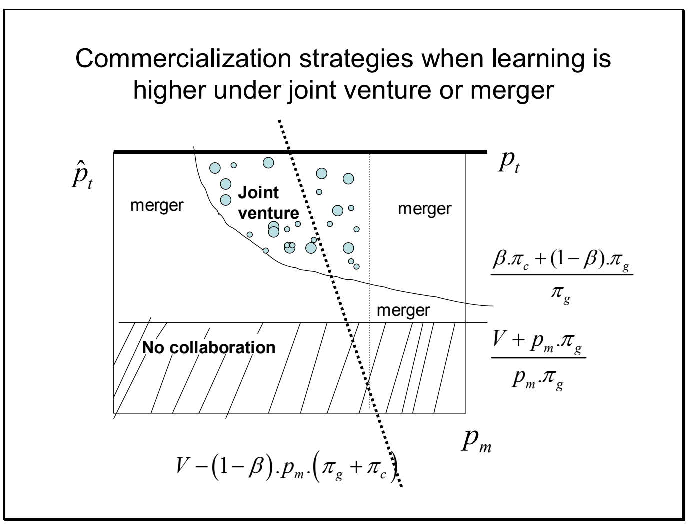
(i) Since the alternative payoffs are the same under a joint venture and a license the result of proposition 1 holds as before.

(ii) From the payoffs we can get that a joint venture yields a higher payoff to the agbiotech firm than a merger if:

$$V-(1-\beta).p_m.(\pi_c+\pi_g)>0 .$$

Clearly, when $p_m=1$, the above inequality cannot hold given our assumption that $V<\pi_c<\pi_g$. The proposition is further illustrated in figure 2.

Figure 2



V =5 ; $\pi_g=30$; ; $\pi_c=10$; $\beta=0.8$; $\hat{p}_t=.8$.

Proposition 3: Whenever the technological competence of the seed firm is higher under a joint venture as compared to under a license:

(i) *Whenever the market competence of a seed firm is low, a license will be preferred to a merger.*

(ii) *Whenever the market competence of a seed firm is high, a license will be preferred to a merger if the brand loyalty to the conventional seed is high. Otherwise, a merger will dominate over a license.*

Whenever $p_t > \hat{p}_t$, a license will be preferred to a joint venture. Furthermore, a license will also dominate a merger if:

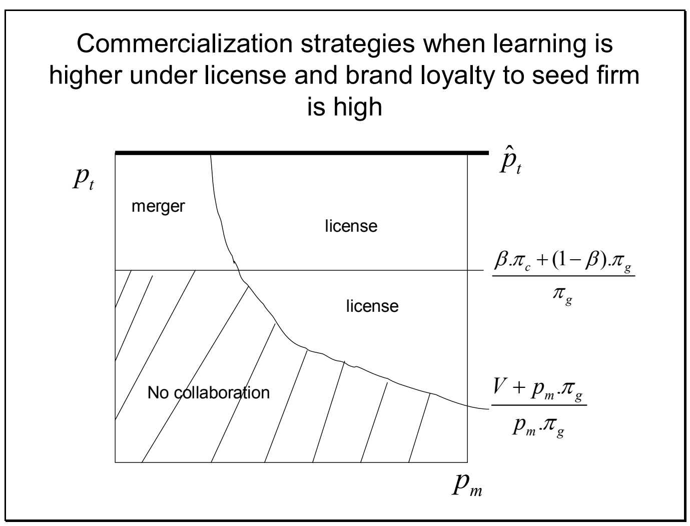
$$V - p_m.\pi_g.\left[(1-\beta)-(p_t-\hat{p}_t)\right]-(1-\beta).p_m.\pi_m > 0.$$

When, the market competence is low or there exists a neighborhood around $p_m = 0$, for which the above equation holds as it is true for $p_m = 0$.

Similarly, consider $p_m = 1$ and $\beta = 1$, then the above equation always hold and hence a license will be preferred. However for $p_m = 1$ and $\beta = 0$ the above equation cannot hold as it contradicts our assumption $V < \pi_c < \pi_g$. Thus for a neighbourdhood around $p_m = 1$ and $\beta = 0$, a merger will dominate over a license. Hence the proof.

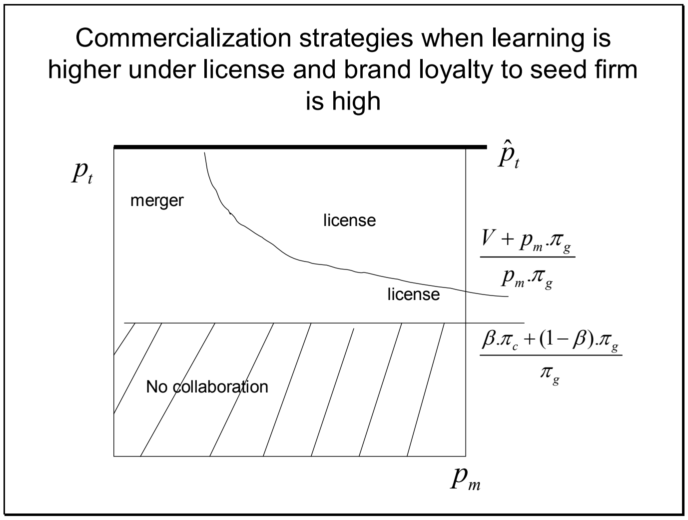
This proposition is furthered illustrated in the two simulations given below.

Figure 3



V =5 ; $\pi_g = 30$; ; $\pi_c = 10$; $\beta = 0.8$; $p_t = .8$.

Figure 4



V =5 ; $\pi_g = 30$; ; $\pi_c = 10$; $\beta = 0.2$; $p_t = .8$.

3. Conclusion

This paper tries to understand the rationality of the commercialization of GMVs worldwide through a case study of Monsanto and its efforts to diffuse Bt cotton. The paper briefly outlined the history of Monsanto and its commercialization strategies in different parts of the world.

It then developed a simple sequential model of technology transfer between an agbiotech firm and a seed firm. It derived a number of propositions on the determinants of the choice of collaboration initiated by the agbiotech firm on the basis of the technological competence and the market share of the eventual GM seed producer (local firm or a joint venture or a merger).

Table 1: Predictions of the model and the possible corresponding situations

Tech learning in license lower than in joint venture + high market share of local seed firm = Joint venture	Tech learning in license lower than in joint venture + high market share of local seed firm = Merger	Tech learning in license higher than in joint venture + low market share of local seed firm = License	Tech learning in license higher than in joint venture + high market share of local seed firm + high brand loyalty to conventional seed = License	Tech learning in license higher than in joint venture + high market share of local seed firm + low brand loyalty to conventional seed = Merger
Argentina, India, China	**Mexico**		**Australia**	**USA**

Table 1 compares the results of the first two sections of this article. At first view the model seems to provide some rationale for the stylized facts. However since this is an ongoing work we cannot comment further before completing the case study.

References

Barwale, R.B; Gadwal, V.R; Zehr, Usha and Zehr, Brent. (2004) "Prospects for Bt Cotton Technology in India." *Agbioforum*, *1&2*(7), pp. 23-26.

Bijman. J, Joly. P-B. (2001) "Innovation challenges for the European agbiotech industry", *Agbioforum*, 4(1), pp 4-13.

Bijman, J. (March 2001). “Restructuring the life science companies.” Biotechnology and Development Monitor **44/45**: 26-32.

Boy, L. "La Question Des Biotechnologies Dans Les Négociations Internationales Sur L'agriculture Et L'environnement." *Terminal*, 2003, (nouvelle série n° 90), pp. 33-52.

FAO. "La Situation Mondiale De L'alimentation Et De L'agriculture 2003-2004" a. FAO Rome, 2004, 632p.

Flack-Zepeda, J. and Traxler, G. (1999) "The Distribution of Benefits from the Introduction of Transgenic Cotton Varieties." *AgBioForum,* 2(2), pp. 94-98.

Fitt, G.P. (2003) "Deployment and impact of Transgenic Bt Cotton in Australia." In N. Kalaitzandonakes (Ed), *the economic and environmental impacts of Agbiotech.*

Gouse, M., Pray, C. and Schimmelpfennig, D. (2004) "The distribution of Benefits from Bt Cotton adoption in South Africa" *AgBioForum,* 7(4), pp. 187-94.

Huang, J., Hu, R., fan, C., Pray, C. and Rozelle, S. (2002) "Bt Cotton benefits, costs and impacts in China" *AgBioForum,* 5(4), pp. 153-66.

Huesing, J. and English, L. (2004) "The Impact of Bt Crops on Developing World." *Agbioforum*, *1&2*(7), pp. 84-95.

Ismael, Y., Bennett, R. and Morse, S. (2002) "Benefits from Bt Cotton use smallholder farmers in South Africa" *AgBioForum,* 5(1), pp. 1-5.

Kirsten, J and Gouse, M. (2003) "The adoption and impact of Agricultural Biotechnology in South Africa" In N. Kalaitzandonakes (Ed), *the economic and environmental impacts of Agbiotech.*

McBride, W. (1999) "Firm-Level Production Effects Related to the Adoption of Genetically Modified Cotton for Pest Management." *AgBioForum,* 2(2), pp. 73-84.

Pray, C. (2001) "Public-private sector linkages in research and development : biotechnology and the seed industry in Brazil, China and India" *American Journal of Agricultural Economics*, 83(3), pp. 742-47.

Pray, C. and Huang, J. (2003) "The impact of Bt Cotton in China" In N. Kalaitzandonakes (Ed), *the economic and environmental impacts of Agbiotech.*

Pray, C., Huang, J. and Qiao, F. (2001) "Impact of Bt Cotton in China" *World Development,* 29 (5), pp. 813-25.

Qaim, C.E. and Zilberman, D. (2003) "Yield effects of genetically modified crops in developing countries" *Science*, 299 pp. 900-02.

Qaim, M. and De Janvry, A. (2003) "Genetically Modified Crops, corporate pricing strategies, and farmers’ adoption: The case of Bt Cotton in Argentina." *American Journal of Agricultural Economics*, 85(4), pp. 814-28.

Quazzo, C., Meunier, E. (2003) "Des Etats-Unis À L'inde : Le Coton Transgénique Tisse Sa Toile." *Inf'OGM*, *4*.

Ramani, S.V; El Aroui, M.A. and Audinet, P.(2001) "Technology Transfer: Partner Selection and Contract Design With Foreign Firms in the Indian Biotechnology Sectors" *The Developing Economies* XXXIX-I pp. 85-111.

Ramani, S.V (2000) "Technology Cooperation between Firms of Developed and Less-Developed Countries" *Economics Letters* 68 203-209.

Rausser, G., S. Scotchmer, et al. (17-18 June, 1999). Intellectual Property and market structure in Agriculture. ICABR conference, "The shaping of the coming agricultural biotechnology transformation: Strategic investment and policy approaches from an economic perspective, Rome.

Sinai;A. (2001) "Comment Monsanto Vend Des Ogm" *Le Monde Diplomatique*, pp. 14-15.

Traxler, G. (1999) "Assessing the prospects for the transfer of genetically modified crops varieties to developing countries" *AgBioForum,* 2(3&4), pp. 198-202.

Traxler, G., Godoy-Avila, S., Flack-Zepeda, J. and Espinosa-Arellano, J. (2003) "Transgenic Cotton in Mexico: A case study of Comarca Lagunera" In N. Kalaitzandonakes (Ed), *the economic and environmental impacts of Agbiotech.*

Traxler, G. and Godoy-Avila, S. (2004) "Transgenic Cotton in Mexico" *AgBioForum,* 7(1&2), pp. 57-62.