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Chapter 6

MNE Led New Market Creation in Emerging Countries: The Case of Bt Cotton

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Abstract

Agri-biotech multinational enterprises (MNEs) are persisting to push genetically modified plant varieties (GMV) worldwide including emerging countries as a technological solution for sustainable development. However, in emerging countries, the structure and effectiveness of regulation and compliance measures to ensure human and environmental safety are much less developed. There are three types of concerns: the economic risks faced by farmers while using existing low-yielding conventional seed varieties, in the face of inadequate institutional mechanisms and safety nets, the long-term environmental risks, and finally, risks posed by other possible externalities. In an attempt to provide some insight on the aforementioned debate, this chapter focuses on a commercially successful GMV—namely genetically modified cotton, also referred to as Bt cotton. The literature on adoption of Bt cotton is first examined, and its findings are confronted with the reality of the introduction and diffusion of Bt cotton in India to derive inferences on how MNE and emerging countries' governments can manage coexistence. Our findings indicate that in order to be successful, MNEs have to establish the sociopolitical legitimacy of GMV through investment in outreach with regulatory authorities, government departments dealing with the environmental and bio safety, farmer groups, and nongovernmental organizations (NGOs). MNEs also have to keep in mind that pricing and high technology fee can become an impediment for the legitimization of technology. Finally,

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MNEs can partner with NGOs to educate and accompany farmers to maximize their livelihood, while preserving the ecological sustainability of their farm lands.

Keywords: Multinational enterprises; agriculture; genetically modified variety; India; emerging countries; new market creation

1. Introduction

In emerging countries, farmers are burdened with an ever-pressing need to increase productivity, which often leads them to apply more chemical inputs such as fertilizers and pesticides. However, over time, this leads to substantial environmental degradation, which lowers soil fertility and ultimately productivity, as illustrated by the yellowing of the Green Revolution (Larson et al., 2004; Murgai, Ali, & Byerlee, 2001). In response, since the 1990s, agri-biotech multinational enterprises (MNEs) like Monsanto, Du pont, and Syngenta have introduced a radical innovation in the form of seeds derived from genetically modified (GM) plant varieties. With desirable traits such as pest resistance, GM seeds lower the need for agrochemicals. At the same time, concerns are being voiced as to whether these GM seeds will turn out to be a poisoned chalice in the long run like the Green Revolution, which caused environmental damage due to its inappropriate implementation by farmers. There are still heated debates worldwide on the consequences of the introduction of GM seeds in production and distribution along agriculture and food value chains.

Even while new genetically modified plant varieties (GMV) continue to be constantly produced, the diffusion of existing GMV remains a bargaining game. The producers of technology, i.e., agri-biotech firms, the producers of seeds, i.e., local seed firms, and the producers of crops, i.e., farmers—compete for the appropriation of value generated by GMV in an environment regulated by the government and influenced by the information meted out by the media and NGOs. Diffusion trajectories depend on the bargaining power of the different types of players within the innovation system. The "precautionary principle," which is at the base of the risk management of coexistence of GMV and conventional varieties, is interpreted differently in North America, Europe, and Asia. For instance, 38 countries have simply banned GMV in all their forms, in an extreme application of the precautionary principle. Moreover, even within countries where they can be grown such as India, South Africa, Brazil, and Canada, there is farmer resistance against GMVs (Eaton, 2013; Scoones, 2008).

Under this context, agri-biotech MNEs are persisting to push GMV worldwide as a technological solution for sustainable development, among others. And the world is yielding. The moratorium against marketing of GM-based food products ended in Europe in 2004 and since then a strict and comprehensive system of regulation has been developed to permit complete traceability in terms of cultivation practices, GM organism levels, and labeling along retail chains. However, in emerging countries, the structure and effectiveness of regulation and compliance measures to ensure human and environmental safety without decreasing the economic returns to the actors along the supply and demand chains are much less developed. Thus, there is a crucial need to understand how an emerging country's systemic actors can address two types of concerns: the economic risks faced by farmers while using existing low-yielding conventional seed varieties, in the face of inadequate institutional mechanisms to provide them insurance, and the long-term environmental risks and other possible social–economical–ecological externalities engendered by the adoption of GMV. In an attempt to provide some insights on the aforementioned debate, the present chapter focuses on a very successful GMV, namely GM cotton, also referred to as Bt cotton. The literature on adoption of Bt cotton is first examined, and its findings are confronted with the reality of the introduction and diffusion of Bt cotton in India to derive inferences on how MNE and emerging countries' governments can manage coexistence.

Bt cotton is so called because it contains the *cry1Ac* gene transferred from a bacterium called *Bacillus thuringiensis*. This gene is responsible for expressing a toxin that kills insect pests popularly known as bollworms, which feed on flowers, buds, and leaves. Thus, whenever a pest eats any part of a Bt plant variety, it dies, thereby limiting losses in yields. By switching to Bt cotton hybrids, farmers have the possibility of reducing yield loss due to pest attack, lowering pesticide spraying and saving on labor costs.

Traditionally, farmers and professional plant breeders developed new plant varieties, including cotton through natural selection, followed by crossbreeding or mutagenesis to get superior yield and agroecological robustness. They employed methods of discovery, selection, and preservation of plant material that were labor intensive, time consuming, and painstakingly cumbersome. In contrast, application of the modern biotech methods ensures direct control over the manipulation of plant genes and enables the achievement of a desired trait in a significantly shorter period. Thus, the modern biotech tools and methods provide GM seeds as a technological solution to the challenge of falling or stagnant agricultural productivity.

The organization of this chapter is as follows. Section 2 presents a meta-analysis of the literature on Bt cotton adoption. Section 3 describes the Indian context. Section 4 captures the findings from the meta-analysis along the context of the case study and finally, Section 5 concludes the discussion.

2. Salient Findings of the Literature on Bt Cotton

2.1. Methodology and Query

In order to identify the drivers and outcomes of Bt cotton adoption, a research query with the terms "Bt AND cotton AND adoption" was applied on SCOPUS, the standard abstract and citation database of peer-reviewed literature. The search was limited to articles, in the social sciences, economics, econometrics, and/or finance subject areas. Articles were manually filtered for fit with the research query. Five broad themes were identified: economics of farming, noneconomic returns to farmers, institutional impact on farmer, systemic economic impact, and systemic ecological impact. All articles seemed to implicitly assume that the objective of the farmer was to maximize profit. Thereafter, a meta-analysis of the abstracts was carried out to answer four questions:

- What are the drivers of adoption of Bt cotton?
- What are the drivers of profit augmentation in the post-adoption period?
- What are the outcomes of Bt cotton adoption?
- What kinds of systemic externalities do the aforementioned behaviors give rise to?

We obtained 61 articles in response to the aforementioned queries. Manual filtering led to the rejection of 18 articles. Out of the remaining 44 articles, 59% described the adoption outcomes to farmers, 39% the systemic externalities, 36% the farmer profile most interested in adoption, and only 16% the drivers of farmer profit in the post-adoption phase.

2.2. Findings

Coming to the first question, drivers of adoption were related to technology attributes, farmer characteristics, and market and systemic features. The technology features that attracted farmers were higher expected profit and lower expected pesticide usage associated with the seed. Other drivers are presented in Table 1.

Table 1. Drivers of Adoption.

Farmer Characteristics that Favor Bt Cotton Adoption
With large farm (21, 54, 55) or with a small farm (42)
With farm of poor soil quality (6, 35, 43, 61)
With better education (56) or knowledge of biotech (55)
With more experience (52) or less experience (42)
With lower aversion to risk (15) or higher health vulnerability (42)
Imitative (55), easily persuaded (55), or information seeking (58)
Market and Systemic Features that Favor Adoption
Lower seed price (6, 35, 43, 61)
Certain quality of seed (35)
Access to effective information (19)
Access to credit (42)
Effective production chains (52)
Popularity (19)
Ease of trade (38)
Influential technology developers (55)
Effective legal protection (61)

Note: Figures within brackets refer to articles in our corpus that can be found in Appendix A.

Table 2. Drivers of Profit in the Post-Adoption Phase.

Drivers of Farmer Profit from Bt Cotton	**Serial No. of Article in Appendix A**
Poorer the farmer or smaller the farm size, higher the profit increase	12, 16
More efficient the farmer or more scale neutral his implementation strategy, higher the profit	14, 56
Systemic features such as better quality of germplasm, lower seed price, lower access to information, lower technology fees augment profit	5, 6, 12, 46

Table 2 presents the features for increase in profit once Bt cotton was adopted. According to the table, not only did richer farmers or those from more developed regions benefit from Bt cotton adoption but also did smaller, poorer farmers.

Turning to the impact of adoption on the farmer as given in Table 3, mainly positive outcomes have been noted in the literature.

Finally, a variety of externalities seem to have been generated within the innovation system following the adoption of Bt cotton in a region. Many of them, as indicated by Table 4, are of a positive nature.

Thus, according to the social sciences literature, the economic impact of Bt cotton on the farmer and the innovation system is mostly positive, although ecological externalities have been noticed. On the basis of such findings, it would seem that any agri-biotech MNE can introduce GMV in emerging countries without problems. To confirm whether it is indeed such a seamless process, we turn to the case study.

3. The Indian Case Study

3.1. Introduction of Bt Cotton in India

From the late 1980s, in India, economic liberalization was introduced in a series of major reforms that allowed both foreign multinationals and large Indian conglomerates

Table 3. Impact of Bt Cotton Adoption on Farmer.

Type of Impact	**Serial No. of Article in Appendix A**
Lower agrochemicals use	1, 3, 4, 6, 8, 9, 12, 16, 17, 21, 27, 28, 30, 33, 40, 56, 57
Higher profit	3, 12, 17, 20, 21, 23, 27, 28, 30, 31, 38, 39, 56
Higher yield	6, 8, 16, 14, 40, 57
Improved health	9, 16, 33, 40
Lower costs	4, 9, 33
Increase in secondary pests	30, 31

Table 4. Systemic Impact Bt Cotton Adoption via Externalities.

Systemic Externality due to Bt Cotton Adoption		
Type of Impact	**Type of Systemic Externality**	**Serial No. of Article in Appendix A**
Health	Health improvement	9, 33, 40
Economic impact	Increased household income of BT cotton adopters	7, 11
	Increased household income of adopters and nonadopters contributing to poverty reduction	8, 49
	Capabilities impact: Spillovers from BT profit impact livelihoods as increased income is reinvested in cotton farming, increasing asset base, and investments in education of children	31
	Employment generation	10
	Choice of farmers to plant BT Cotton has majorly wiped out local (Desi) varieties that produces coarse raw cotton needed by the surgical cotton industry from the market	51
	Release of labor for other activities	20
Ecological impact	Groundwater and soil contamination decrease due to lowered use of agrochemicals	33, 40
	Increase in biodiversity due to lower contamination	33
	Secondary pest increase	1, 30
	Increase of other arthropod predator populations	2

to enter the seeds sector. The embrace of market capitalism coincided with the fading away of international public organizations and the rise of private firms as the major players in the Indian agricultural innovation system. The market share of private firms in the seeds markets increased dramatically. Similarly, private companies including multinationals began to dominate the pesticides and fertilizers markets. While the role of the state as a supplier in the seed markets diminished over time, the regulatory bureaucracy involved in the post-production phase of seeds was expanded and tightened through the setup of institutions and a framework for seed quality evaluation and certification (Pray et al., 2001).

In terms of innovation, the enormous success of the Green Revolution of the previous decades had engendered a winner's curse. The Indian agricultural research system had a near-unique focus on the creation of modern varieties by using the Green Revolution technology to the utter neglect of new fields like biotechnology till it was forced upon them. Pray and Nagarajan (2014) also point out that scientists were not used to working in multidisciplinary teams (e.g., with scientists from different branches such as agronomy, plant breeding, plant pathology, entomology, and biotechnology) required for the development of transgenes for commercial use, and they were not familiar with the protocols for satisfying regulatory requirements. Moreover, as part of the reform package in 1991, public spending on agricultural research was cut, lowering the incentives for innovation creation even further. Thus, by the beginning of the 1990s, grave productivity problems in agriculture, widely acknowledged ecological degradation, coupled with market freedom ushered in by economic liberalization, paved the way for leading international agri-biotechnology firms to enter the Indian innovation system.

By the start of the 1990s, Indian cotton yields were among the lowest in the world, with high cost of cultivation, poor quality seeds, and poor fiber attributes of hybrids, which deteriorated rapidly with successive pickings. The consumption of pesticides by cotton cultivation was as high as 54% of the total pesticide consumption in the country. This high usage of pesticides was an attempt by the farmers to save the produce from pernicious bollworms, increasing the burden on poor farmers and severely damaging the environment (Raghuram, 2002).

In the meantime, far earlier, in 1911 in the province of Thuringia, in Germany, a scientist discovered that a commonly occurring bacterium of the region, called *B. thuringiensis,* could act as an insecticide against the local "flour moth." This led to the commercialization of an insecticide by using this bacterium in France in 1938 and in the United States during the 1950s. Subsequent generations of the product were marketed in the form of a bacterial spray. Around 1982, scientists at Monsanto, a leading agrochemicals company then, and a world-leader in agri-biotechnology now, succeeded in isolating the genes of the Cry family responsible for the production of the toxin in the bacteria, which is reputed to provide a high degree of resistance to major insect pests such as bollworms. Then, they inserted the gene from *B. thuringiensis* into crops such as cotton and corn, which came to be referred to as Bt cotton and Bt corn. This constituted a radical technological breakthrough in plant production technologies. Bt cotton is a typical example of a GM plant variety producing its own insecticide, a Bt protein-based toxin that kills the pest when it ingests any part of the plant.

Monsanto commercialized Bt cotton varieties in the United States by 1995 and began to seek to introduce it in other countries. However, a feature of GMV is their fragility, which means that to diffuse an original GMV in a new country, it has to be crossed with a robust local variety to create the Bt cotton seed most suitable for the local agroecology. With foresight, Monsanto reached out to an emerging country's targets even before it commercialized Bt cotton in the United States. For instance, in India, Monsanto approached the government in 1990 itself, to get approval to license its variety, but this was refused, as the technology fees were deemed too high (Newell, 2003). Then Monsanto approached Mahyco, the biggest Indian seed company. Mahyco was established in 1964 in Maharashtra, India, by Badrinarayan R. Barwale, a respected plant scientist who was to win the prestigious World Food Prize in 1998. Mahyco applied to the Department of Biotechnology (DBT), an agency under the aegis of the Ministry of Science and Technology to import 100 g of Bt cotton seeds developed by Monsanto. Authorization was obtained in March 1995 and the process of crossing the American Bt cotton variety with the Indian ones began. In 1998, Monsanto obtained a 26% stake in Mahyco, and it also created a joint venture, the Mahyco Monsanto Biotech company (MMB) in which each firm has a 50% equity holding.

3.2. Controversy Generation

After 3 years, in April 1998, Mahyco got the green signal from the DBT to carry out small trials of Bt cotton, using 100 g of seeds in each trial plot. However, the company did not restrict itself to these small trials, drawing the attention of activists. Thus, in November 1998, the farmers group Karnataka Rajya Raitha Sangha (KRRS) burnt crops under field trials. In January 1999, a case challenging the legality of the field trials authorized by the DBT was filed by well-known activist Vandana Shiva in the Supreme Court.

In July 2000, DBT granted permission to Mahyco to conduct large-scale field trials including seed production at 40 sites in six major cotton-growing states with the results to be monitored by the DBT. Nevertheless, a year later, in June 2001, the Genetic Engineering Approval Committee (GEAC) of the Ministry of Environment insisted that field trials of Bt cotton be extended by another year and that large-scale field trials on 100 hectares be conducted again in seven states to establish their safety. These field trials were also to be monitored by the Indian Council of Agricultural Research (ICAR). Thus the commercialization of Bt cotton was delayed by an additional year of field testing due to protests from activists such as Vandana Shiva, Nanjundaswamy (KRRS), and NGOs such as Gene Campaign and Green Peace-India.

While the deliberations on the safety of Bt cotton were going on, in 2001, a bollworm infestation swept through the state of Gujarat, but in some zones the cotton crop was unaffected raising suspicions. MMB filed a complaint to GEAC on industrial misconduct by a local seed firm, whereby Bt cotton seeds had been diffused and planted at a time when commercialization had not been approved in India. Navbharat Seeds, the company selling the illegal variety claimed that their hybrids were developed from insect resistant plants carefully chosen from a bollworm infested field. MMB could not press charges against Navbharat Seeds for its Bt-gene was not patent protected in India. Moreover, although GEAC immediately threatened to burn the cotton fields grown with Navbharat Seeds, nothing could be done because of farmer protests.

A year later, in March 2002, the GEAC approved the commercialization of three varieties of insect-resistant Bt cotton hybrids (Mech-12 Bt, Mech-162 Bt, and Mech-184 Bt), under the brand name Bollgard® in the central and southern cotton-growing zones for the 2002–2003 growing season. Authorization for commercialization was granted for the period April 2002 to March 2005 under the condition that any farmer using the Bt cotton plants refuge zones with non-Bt Cotton covering at least 20% of the cultivated land. The refuge was to act as a barrier to pollen spread and prevent the development of insect resistance. Second, Mahyco had to submit the data on the field trials every year to the GEAC. In May 2005, the GEAC permitted the commercialization of six more Bt cotton hybrids of MMB for the northern states (Jayaraman, 2000, 2001a, 2001b, 2004).

There are regular reports in the media about four types of problems. First, in markets, seed quality is not being controlled. Since 2002 an illegal market for Bt cotton seeds, i.e., seeds which have not been validated by the Indian biosafety regulatory system before entering the market has grown steadily. Demand for illegal seeds is high due to their confirmed ability to resist bollworm and their low price (Jayaraman, 2004). The market for unauthorized seeds is also supported by the development of new varieties created by local farming ingenuity and by informal social networks between farmers based on trust, although their quality is affirmed to be lower than that of the legal seeds (Morse et al., 2005). Second, a high degree of variance in returns to Bt cotton is claimed to be increasing farmer indebtedness. Third, negative externalities in the form of an increased incidence of secondary pests and resistance build-up in target pests has been noted (Qayum & Sakkhari, 2006; Ramanjaneyulu & Kuruganti, 2006; Shiva & Jafri, 2004). Lastly, death of livestock through eating Bt cotton residues have been reported in newspapers highlighting health risks (Bell et al., 1999).

3.3. Policy Swings

In 2009, Mahyco, in collaboration with Monsanto, applied for authorization to bring out a GM vegetable variety, Bt brinjal (*Solanum melongena*, also known as eggplant), into the Indian market. However, after this was granted by GEAC, there were protests from civil society groups and anti-GM activists. In response, in 2010, the Ministry of Environment imposed an indefinite moratorium on the cultivation of Bt brinjal. Further, the ministry initiated a series of public consultations and commissioned two studies to make an informed decision on the future of GM crops. First, the Parliamentary Standing Committee Reports on GM crops opined that the benefits of Bt cotton had not trickled down well to poor farmers and the state actors including ministries and the regulatory body are simply not ready for future GM crops. Second, the Supreme Court appointed a "Technical Expert Committee" to review the existing regulatory procedures for reducing the risks associated with GM crops. In July 2013, its final report stated that unless the gaps in India's regulatory system could be addressed, field trials of GM crops and the commercialization of Bt Brinjal was not advisable. However, in 2014, a new neo-liberal government favoring further economic liberalization was elected into power in India, and the new Minister of Environment proclaimed in the Parliament that GM crop research is in the national interest. Thus, in July 2014, GEAC cleared the approval of field trials for a range of food crops including rice, mustard, cotton, chickpea, and brinjal (Menon, 2014).

3.4. Present Situation

By 2013, about 7.32 million farmers had planted roughly 11 million hectares of land with Bt, ranking India fourth in the world in terms of land devoted to GM plant varieties, after the United States, Brazil, and Argentina. The success of Bt triggered changes in firm strategy and consequently the market. Indian seed firms increased their R&D investments, and sales of GM seeds, molecular markers, and related tools in India grew from approximately US$17 million to 490 million between 2002–2003 and 2011–2012 (Thutupalli & Iizuka, 2016). By 2012, there were 1128 Bt technology–based cotton hybrids selling in India out of which 982 had Monsanto's genes. Despite this immense commercial triumph, societal debates on the long-term environmental and livelihood impact of Bt adoption continue.

4. Discussion of Findings

The literature survey confirmed that GMV-like Bt cotton has the potential to contribute to sustainable development given that the systemic externalities are monitored and addressed in case of need. Studies of adoption in diverse parts of the world confirmed its suitability for adoption by a variety of farmers, rich or poor, highly knowledgeable and skilled or otherwise, information seeking or imitative. Indeed, there are no results on which kind of farmer would not benefit from adopting Bt cotton. Adoption reduces the use of agrochemicals on farmland, lowers the costs of production, and thereby, increases profit. The magnitude of the profit decreases, however, with a higher price of the Bt cotton seed. Due to reduction in the use of agrochemicals on farmlands, contamination falls and health improves.

The meta-analysis also gives a number of pointers for MNEs for sustainable development. They must collaborate to cross-breed their GMV with local seed producers who can provide good germplasm. The latter must also be influential developers. Prices must be affordable and clearly indicate quality. Production and distribution chains must be effective. Most importantly, effective communication and marketing strategies must ensure access to information and build popularity of the brand.

An emerging country's market is suitable for entry, if, besides offering a substantial size, farmers in these markets can have easy access to credit, and there is ease of trade and effective legal protection. In addition, local firms must have the absorptive capacity to receive the technology transfer and crossbreed the GMV with local varieties. In turn, emerging countries' governments have to reflect on whether or not to ban GMV according to their contextual needs. On the one hand, the literature affirms that through reduced use of agrochemicals, Bt cotton can lower environmental contamination, increase biodiversity, improve the health of the farming community, increase the household income of both adopters and nonadopters, release labor for other work, and build human capital in the process. On the other hand, secondary pest and other populations can increase, there can also be loss of diversity as the local varieties are eliminated, and the released labor may add to socioeconomic tensions.

Taking a cue from the triple bottom line, "People, Profit, and Planet," proposed by Elkington (1999), sustainability from a firm's perspective can be considered as a three-dimensional vector. The three components refer to legitimacy attainment from consumers, firm employees and shareholders, and the environment, respectively. Elkington (1999) affirmed that all three dimensions have to be addressed by an MNE in its new product introduction for sustainability. For instance, in the case of Monsanto, farmers benefitted from increased productivity and health improvements due to lower use of pesticides. Monsanto secured a loyal consumer base. The cotton lands benefitted from lower environmental degradation. Thus, by successfully maneuvering the interrelationships between the three components of the sustainability vector, Monsanto was able to gain reputational, economical, and societal value which contributed to the innovation's commercial success and acceptance. Further through its localization efforts and successful collaborations, Monsanto could mitigate controversy. In this manner, the strategic success of Monsanto in India adds four more insights for agri-biotech MNEs for sustainable development.

Product and business legitimacy are necessary for successful commercialization of GMV: Even if GMV can be redesigned without problem for an emerging country via collaboration with local firms, because of its intrinsic nature, as a radical innovation that can trigger systemic ecological externalities, agri-biotech MNEs may need to cross a variety of hurdles for successful commercialization. New product introduction may especially trigger systemic challenges, if GMV legitimacy is not accepted by key emerging country's stakeholders. Monsanto faced direct challenges in India with public agencies and NGOs due to concerns about the long-term impact of Bt cotton on human health and the ecology. Therefore, prior to and during the process of product introduction, MNEs should invest in establishing product, business, and social legitimacy in an emerging country, barring which its new product introduction may fail.

Stronger the potential value of GMV to farmers, greater the credibility of GMV: Monsanto concentrated on product performance to create a product that would reduce the cost of production of farmers the most. Of course, it was aware of the value of its innovation in terms of positive externalities, as the farmers would benefit from both higher yields of cotton and reduced pesticide-related health hazards. But the objective was to maximize the quality improvement of the seed so that it could be sold at the highest possible price to farmers and still displace the available seeds in the market developed by local breeders and public research institutions. Here, the product value was embodied in the benefits to the environment and the health of farmers, and it helped to justify a high price of Bt cotton.

Greater the MNE outreach to farmers, better the bargaining position of MNE: MMB faced conflicts with other stakeholders and won, because its consumers, namely farmers, gave it support. Since farmers were very happy with the innovation, they pressurized the Indian government to legalize Bt cotton and overlook the violations made during testing. Indeed, the farmers who used the Bt cotton seeds without knowing the full implication of the use of GM seeds in the long run and who enjoyed higher yields as well as reduced health hazards from the pesticides, formed a large constituency to force the Indian government to ignore the apprehensions held by NGOs opposed to GMV and MMB. In order to take the farmers in confidence, MMB also committed to various CSR projects most of which were not directly related to the innovation. This kind of nonstrategic CSR also helped to tide over the resistance put up by the concerned authorities and NGOs at the commercialization stage.

Greater the collaboration with local actors in the innovation system and greater the exercise of strategic patience, higher the long-term returns to the MNE: When challenges are issued by the state, regulatory agencies, and civil society groups, legitimization efforts by way of strategic patience, collaboration, or compromise should be explored before confrontation is launched. For instance, Monsanto was forced to compromise on technology fees in order to attain legitimacy, and it chose not to initiate a confrontation at this stage. However, this tactic paid off well. Through an astute mix of strategic patience and compromise with public agencies and NGOs and fruitful collaborations and agreements with local firms, Monsanto was able to successfully commercialize Bt cotton in India.

This completes our discussion. At this juncture, the limitations of this study, which also point to avenues of further research, must be stated. The focus of this chapter has been on Bt cotton and its commercialization experience in India. For a deeper and broader understanding of the implications of GMVs for the emerging world at least five kinds of comparative studies must be pursued. First, the impact of different kinds of GMVs such as Bt corn, Bt soybean, and Bt flax must be studied with special attention being paid to consumable plant varieties such as Bt papaya, Bt potato, etc., which may have consequences on human health in the long run. Second, the impact on the socio-economic fabric is usually the point of focus of economists, but they must also strive to understand and monetize the long-run impact on the ecology. Third, the experiences of different countries must be compared. The Chinese trajectory is particularly worthwhile for study, for it now has world class public research centers with renowned research and innovation capabilities in GMVs. Fourth, the policy evolution and capabilities of developed and developing countries must be compared. Fifth, the United States, which was the outspoken advocate of no regulation on diffusion of GMV during the beginning of the millennium, has reverted back to placing accountability on the MNE (Ramani & Thutupalli, 2015). However, most emerging countries under pressure from United States have done away with regulation, and thus, it is necessary to examine what is possible in emerging countries given their limited regulatory capabilities to protect the environment.

5. Concluding Remarks

The objective of this study was to explore if and how MNEs' diffusing GMV in emerging countries can contribute to sustainable development in the agriculture sector taking Bt cotton as an example of a successfully diffused GMV. A survey of the literature on adoption of Bt cotton led to the identification of the drivers of adoption, drivers of profit in the post-adoption phase, and the larger impact of adoption. The findings indicated that although some systemic ecological externalities are possible, over all, the economic impact on the farmer and the system, are likely to be positive. These were confronted with the case study of the introduction of Bt cotton in India by Monsanto. Taken together, the two studies offer the following inferences for agri-biotech MNEs diffusing GMV in emerging countries.

Even if an innovation is largely confirmed as supporting sustainable development, if its legitimacy is marred by long-term uncertainties about its impact on the environment and/or local communities, MNEs may face roadblocks. Agri-biotech MNEs can be challenged by local civil society, farmers groups, and even the state itself while commercializing GMV in emerging countries. To minimize the probability of such confrontations, MNEs have to veer away from an excessive focus on reduction of techno-commercial uncertainty and innovation rent-seeking and also invest in establishing the sociopolitical legitimacy of GMV. The societal confrontation has three components: uncertainty, ideology, and access.

It is difficult, if not impossible, to ascertain with precision, the medium- to long-term risks (or even benefits) of the new seed technology from the laboratory or field trial data because of the genuine scientific uncertainty that accompanies any radical emerging technology. Any new technology has to withstand the test of time. Therefore, MNEs have to invest in outreach with regulatory authorities, government departments dealing with the environmental and bio safety, farmer groups, and NGOs in order to diffuse GMV.

Worldwide there is an ideological clash between agri-biotech MNEs and societal stakeholders over GMV, because the latter are concerned about the loss of sovereignty over seeds, an essential commodity. Local actors are forced to question the legitimacy of the technology and its carrier—namely the MNE, given that seeds form the basis of all sustenance. Indeed the prospect of the propriety rights of good quality seeds moving entirely into private hands is triggering reflection. Many policy and civil society representatives are concerned about the present tight proprietary regime in the form of patents for life forms, plant breeder's rights, and their strict enforcement via Trade-Related Aspects of Intellectual Property Rights (TRIPS). Partnerships with local seed firms and public laboratories can reduce this anxiety.

In any sector, when MNEs diffuse an innovation that can benefit the poorer sections of society, ensuring maximal access is crucial to circumvent social tensions. High royalties or technology fees increase the socioeconomic uncertainty for small farmers and cast questions on the legitimacy of the technology and the MNE's operation in the host country. MNEs have to keep in mind that pricing and high technology fee can become an impediment for the legitimization of technology.

In the face of such challenges, one of the best ways for an agri-biotech MNE to construct legitimacy is to educate and accompany farmers to maximize their livelihood, while preserving the ecological sustainability of their farm lands. MNEs can seek to affirm their corporate social responsibility through such outreach to farmers. The returns, however, are likely to more than compensate MNEs as farmers can also become brand ambassadors of GMV, if their adoption increases their income and well-being.

Finally, in addition to legitimacy construction, MNEs have to focus on product quality, effective communication and advertising, easy access to supply and well-functioning production and distribution chains for successful commercialization and social acceptance of GMV.

References

Bell, A. (1999). Diseases of cotton. *Cotton: Origin, history, technology and production.* New York: John Wiley and Sons, Inc.

Eaton, E. (2013). *Growing resistance: Canadian farmers and the politics of genetically modified wheat*, Univ. of Manitoba Press.

Jayaraman, K. S. (2000). India okays GM cotton. *Nature Biotechnology, 18*, 582.

Jayaraman, K. S. (2001a). India backtracks on Bt cotton. *Nature Biotechnology, 19*, 703.

Jayaraman, K. S. (2001b). Illegal Bt cotton in India haunts regulators. *Nature Biotechnology, 19*, 1090.

Jayaraman, K. S. 2004. Illegal seeds overtake India's cotton fields. *Nature Biotechnology, 22*, 1333–1334.

Larson, D., Jones, E., Pannu, R., & R. S. (2004). Instability in Indian agriculture: A challenge to the Green Revolution technology. *Food Policy, 29*, 257–273.

Menon, M. (18 July 2014). GEAC clears field trials for GM crops. *The Hindu.*

Morse, S., Bennett, R., & Ismael, Y. (2005). Comparing the performance of official and unofficial genetically modified cotton in India. *AgBioForum, 8*, 1–6.

Murgai, R., Ali, M., & Byerlee, D. (2001). Productivity growth and sustainability in post-green revolution agriculture: the case for the Indian and Pakistan Punjabs. *World Bank Research Observer, 16*, 199–218.

Newell, P. (2003). Biotech firms, biotech politics: Negotiating GMO's in India. *IDS working paper, Biotechnology policy series.* Brighton, UK.

Pray, C., Ramaswami, B., & Kelley, T. (2001). The impact of economic reforms on R&D by the Indian seed industry. *Food Policy, 26*, 587–598.

Pray, C. E., & Nagarajan, L. (2014). Innovations in Indian seed/biotech industry. In Ramani, S. V. (Ed.), *Innovation in India: Combining economic growth with inclusive development.* Delhi: Cambridge University Press.

Raghuram, N. (2002). India joins the GM club. *Trends in Plant Science, 7*, 322–323.

Ramani, S. V., & Thutupalli, A. (2015). Emergence of controversy in technology transitions: Green revolution and Bt cotton in India. *Technological Forecasting and Social Change, 100*, 198–212.

Ramanjaneyulu, G., & Kuruganti, K. (2006). Bt cotton in India: Sustainable pest management? *Economic and Political weekly*, 561–563.

Scoones, I. (2008). Mobilizing against GM crops in India, South Africa and Brazil. *Journal of Agrarian Change, 8*, 315–344.

Shiva, V., & Jafri, A. (2004). *Failure of GMOs in India (synthesis/regeneration, 33/winter)*. New Delhi, India: Research Foundation for Science, Technology and Ecology.
Thutupalli, A., & Iizuka, M. (2016). Catching-up in agricultural innovation: The case of *Bacillus thuringiensis* cotton in India. *Industrial and Corporate Change, 25*, 923–940.

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APPENDIX A

Corpus for Meta-Analysis

No.	Citation
1	Lu, Y., Wu, K., Jiang, Y., Xia, B., Li, P., Feng, H., Wyckhuys, K. A. G., & Guo, Y. (2010). Mirid bug outbreaks in multiple crops correlated with wide-scale adoption of Bt cotton in China. *Science, 328*, 1151–1154.
2	Lu, Y., Wu, K., Jiang, Y., Guo, Y., & Desneux, N. (2012). Widespread adoption of Bt cotton and insecticide decrease promotes biocontrol services. *Nature, 487*, 362–365.
3	Thirtle, C., Beyers, L., Ismael, Y., & Piesse, J. (2003). Can GM-Technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal. *World Development, 31*, 717–732.
4	Huang, J., Hu, R., Rozelle, S., Qiao, F., & Pray, C. E. (2002). Transgenic varieties and productivity of smallholder cotton farmers in China. *Australian Journal of Agricultural and Resource Economics, 46*, 367–387.
5	Qaim, M., Subramanian, A., Naik, G., & Zilberman, D. (2006). Adoption of Bt cotton and impact variability: Insights from India. *Review of Agricultural Economics, 28*, 48–58.
6	Qaim, M., & 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*, 814–828.
7	Kathage, J., & Qaim, M. (2012). Economic impacts and impact dynamics of Bt (*Bacillus thuringiensis*) cotton in India. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 11652–11656.
8	Ali, A., & Abdulai, A. (2010). The adoption of genetically modified cotton and poverty reduction in Pakistan. *Journal of Agricultural Economics, 61*, 175–192.
9	Kouser, S., & Qaim, M. (2011). Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis. *Ecological Economics, 70*, 2105–2113.
10	Subramanian, A., & Qaim, M. (2009). Village-wide effects of agricultural biotechnology: The case of Bt cotton in India. *World Development, 37*, 256–267.
11	Subramanian, A., & Qaim, M. (2010). The impact of Bt cotton on poor households in rural India. *Journal of Development Studies, 46*, 295–311.
12	Stone, G. D. (2011). Field versus farm in Warangal: Bt cotton, higher yields, and larger questions. *World Development, 39*, 387–398.
13	Hubbell, B. J., Marra, M. C., & Carlson, G. A. (2000). Estimating the demand for a new technology: Bt cotton and insecticide policies. *American Journal of Agricultural Economics, 82*, 118–132.

Appendix A. Continued.

No.	Citation
14	Crost, B., Shankar, B., Bennett, R., & Morse, S. (2007). Bias from farmer self-selection in genetically modified crop productivity estimates: Evidence from Indian data. *Journal of Agricultural Economics, 58*, 24–36.
15	Liu, E. M. (2013). Time to change what to sow: Risk preferences and technology adoption decisions of cotton farmers in China. *Review of Economics and Statistics, 95*, 1386–1403.
16	Bennett, R., Morse, S., & Ismael, Y. 2006. The economic impact of genetically modified cotton on South African smallholders: Yield, profit and health effects. *Journal of Development Studies, 42*, 662–677.
17	Sadashivappa, P., & Qaim, M. (2009). Bt cotton in India: Development of benefits and the role of government seed price interventions. *AgBioForum, 12*.
18	Carrière, Y., Ellers-Kirk, C., Hartfield, K., Larocque, G., Degain, B., Dutilleul, P., …, Tabashnik, B. E. 2012. Large-scale, spatially-explicit test of the refuge strategy for delaying insecticide resistance. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 775–780.
19	Marra, M. C., Hubbell, B. J., & Carlson, G. A. (2001). Information quality, technology depreciation, and Bt cotton adoption in the southeast. *Journal of Agricultural and Resource Economics, 26*, 158–175.
20	Elbehri, A., & Macdonald, S. (2004). Estimating The Impact Of Transgenic Bt Cotton On West And Central Africa: A General Equilibrium Approach. *World Development, 32*, 2049–2064.
21	Finger, R., Benni, N. E., Kaphengst, T., Evans, C., Herbert, S., Lehmann, B., Morse, S., & Stupak, N. (2011). A meta analysis on farm-level costs and benefits of GM crops. *Sustainability, 3*, 743–762.
22	Herring, R. J., & Chandrasekhara Rao, N. (2012). On the 'failure of Bt cotton': Analysing a decade of experience. *Economic and Political Weekly, 47*, 45–53.
23	Gouse, M., Kirsten, J. F., & Jenkins, L. (2003). BT cotton in South Africa: Adoption and the impact on farm incomes amongst small-scale and large scale farmers. *Agrekon, 42*, 15–29.
24	Lybbert, T. J., & Bell, A. (2010). Stochastic benefit streams, learning, and technology diffusion: Why drought tolerance is not the new Bt. *AgBioForum, 13*.
25	Schnurr, M. A. (2012). Inventing Makhathini: Creating a prototype for the dissemination of genetically modified crops into Africa. *Geoforum, 43*, 784–792.
26	Frisvold, G. B., & Reeves, J. M. (2008). The costs and benefits of refuge requirements: The case of Bt cotton. *Ecological Economics, 65*, 87–97.

Appendix A. Continued.

No.	Citation
27	Vitale, J., Ouattarra, M., & Vognan, G. (2011). Enhancing sustainability of cotton production systems in west Africa: A summary of empirical evidence from Burkina Faso. *Sustainability, 3*, 1136–1169.
28	Vitale, J. D., Vognan, G., Ouattarra, M., & Traore, O. (2010). The commercial application of GMO crops in Africa: Burkina Faso's decade of experience with Bt cotton. *AgBioForum, 13*, 320–332.
29	Hu, R., Pray, C., Huang, J., Rozelle, S., Fan, C., & Zhang, C. (2009). Reforming intellectual property rights and the Bt cotton seed industry in China: Who benefits from policy reform? *Research Policy, 38*, 793–801.
30	Dowd-Uribe, B. (2014). Engineering yields and inequality? How institutions and agro-ecology shape Bt cotton outcomes in Burkina Faso. *Geoforum, 53*, 161–171.
31	Morse, S., & Bennett, R. (2008). Impact of Bt cotton on farmer livelihoods in South Africa. *International Journal of Biotechnology, 10*, 224–239.
32	Crost, B., & Shankar, B. (2008). Bt-cotton and production risk: Panel data estimates. *International Journal of Biotechnology, 10*, 122–131.
33	Kouser, S., & Qaim, M. (2013). Valuing financial, health, and environmental benefits of Bt cotton in Pakistan. *Agricultural Economics (United Kingdom), 44*, 323–335.
34	Herring, R. J. (2015). State science, risk and agricultural biotechnology: Bt cotton to Bt Brinjal in India. *Journal of Peasant Studies, 42*, 159–186.
35	Fok, M. (2011). Variety market development: A Bt cotton cropping factor and constraint in China. *AgBioForum, 14*, 47–60.
36	Adenle, A. A., Morris, E. J., & Parayil, G. (2013). Status of development, regulation and adoption of GM agriculture in Africa: Views and positions of stakeholder groups. *Food Policy, 43*, 159–166.
37	Smale, M. 2012. Rough terrain for research: Studying early adopters of biotech crops. *AgBioForum, 15*, 114–124.
38	Bouët, A., & Gruère, G. P. (2011). Refining opportunity cost estimates of not adopting GM cotton: An application in seven Sub-Saharan African countries. *Applied Economic Perspectives and Policy, 33*, 260–279.
39	Qiao, F. (2015). Fifteen years of Bt cotton in China: The economic impact and its dynamics. *World Development, 70*, 177–185.
40	Abedullah, Kouser, S., & Qaim, M. (2015). Bt cotton, pesticide use and environmental efficiency in Pakistan. *Journal of Agricultural Economics, 66*, 66–86.
41	Spielman, D. J., Nazli, H., Ma, X., Zambrano, P., & Zaidi, F. (2015). Technological opportunity, regulatory uncertainty, and Bt cotton in Pakistan. *AgBioForum, 18*, 98–112.
42	Mal, P., Anik, A. R., Bauer, S., & Schmitz, P. M. (2012). Bt cotton adoption: A double-hurdle approach for North Indian Farmers. *AgBioForum, 15*, 294–302.

Appendix A. Continued.

No.	Citation
43	Arora, A., & Bansal, S. (2012). Diffusion of Bt cotton in India: Impact of seed prices and varietal approval. *Applied Economic Perspectives and Policy, 34*, 102–118.
44	Banerjee, S. B., & Martin, S. W. (2009). A binary logit analysis of factors impacting adoption of genetically modified cotton. *AgBioForum, 12*.
45	Ceddia, M. G., Goméz-Barbero, M., & Rodríguez-Cerezo, E. 2008. An ex-ante evaluation of the economic impact of Bt cotton adoption by Spanish farmers facing the EU cotton sector reform. *AgBioForum, 11*, 82–92.
46	Hofs, J. L., & Berti, F. (2006). Genetically modified cotton (*Gossypium hirsutum* L. Bt.): What future for small family farms in French-speaking Africa? *Biotechnology, Agronomy and Society and Environment, 10*, 335–343.
47	Qiao, F., & Yao, Y. (2015). Is the economic benefit of Bt cotton dying away in China. *China Agricultural Economic Review, 7*, 322–326.
48	Linacre, N. A., & Birner, R. (2013). Financing of regional biotechnology regulations: Lessons from West Africa. *AgBioForum, 16*, 88–103.
49	Qiao, F., Huang, J., & Zhang, C. (2016). The sustainability of the farm-level impact of Bt cotton in China. *Journal of Agricultural Economics, 67*, 602–618.
50	Desmond, E. (2016). The legitimation of development and GM crops: The case of Bt Cotton and Indebtedness in Telangana, India. *World Development Perspectives, 1*, 23–25.
51	Venugopalan, M. V., Kranthi, K. R., Lakade, S., & Tandulkar, N. R. (2016). Development of agro-technology to increase yields of a shy-bearer desi cotton species, *Gossypium arboreum* race cernuum in a non-traditional area of cultivation. *Current Science, 110*, 692–695.
52	Maia, A. G., Miyamoto, B. C. B., & Silveira, J. M. F. J. (2016). A adoção de Sistemas Produtivos entre grupos de pequenos produtores de algodão no Brasil. *Revista de Economia e Sociologia Rural, 54*, 203–220.
53	Menon, S., & Jha, S. K. (2016). National biosafety system for regulating agricultural biotechnology in India. *International Journal of Biotechnology, 14*, 151–169.
54	Ramani, S. V., & Thutupalli, A. (2015). Emergence of controversy in technology transitions: Green revolution and Bt cotton in India. *Technological Forecasting and Social Change, 100*, 198–212.
55	Wang, X., Xiang, C., & Huang, J. (2015). Adoption and uptake pathway of GM technology by Chinese smallholders: Evidence from Bt cotton production. *AgBioForum, 18*, 55–70.
56	Sadashivappa, P. (2015). Socio-economic impacts of Bt cotton adoption in India: Evidence from panel data. *AgBioForum, 18*, 193–208.
57	Nagarajan, L., Pray, C. E., & Naseem, A. (2015). Empirical analysis on the impact of private-sector R&D on cotton productivity in India. *AgBioForum, 18*, 182–192.

Appendix A. Continued.

No.	Citation
58	Lalitha, N. & Viswanathan, P. K. (2015). Technology diffusion and adoption in cotton cultivation: Emerging scenario in Gujarat. *AgBioForum, 18*, 209–220.
59	Abraham, A. (2014). Genetic engineering technologies for Ethiopian agriculture: Prospects and challenges. *Journal of Commercial Biotechnology, 20*, 7–16.
60	2010. Bt variety gives hope for domestic cotton industry. *Textiles South East Asia, 7*, 5–6.
61	Narayanan, K. K. (2006). Giving farmers a technology choice. *Asian Textile Journal, 15*, 65–66.