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Liberalization, Biotechnology and the Private Seed Sector: The Case of India's Cotton Seed Market

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Abstract

Liberalization, stronger intellectual property rights laws and the commercialization of biotechnology have led the private sector to become an important supplier of varietal technology in agriculture in developed and developing countries. The departure from the public sector driven Green Revolution model has given rise to new concerns about competition in the seed market. India's cotton seed market exemplifies these new developments. This study examines the evolution in its market structure and the factors that underlie the changes.

The study finds that while the private sector has grown rapidly in the last decade (when these policies and technological developments were operative), their dominance of the market cannot be ascribed directly to any of the conventionally cited factors. Furthermore, despite more than a decade after the removal of FDI restrictions, the presence of foreign majors is limited. The rapid growth has been driven by domestic firms.

The growth was not accompanied by greater consolidation in the industry. As the proprietary market has grown, more private players have come into the market eating away at the share of the market leaders. However, the leading brands do possess some market power which at the retail level is shared with the seed dealer.

With Bt cotton, the seed industry encompasses a seed market as well as a technology market. To some extent, biosafety laws have protected the monopoly of the incumbent which has received a significant first mover advantage. However, the market structure is not frozen because of diffusion from illegal seeds, competition from alternative gene suppliers and changing regulatory practices.

Keywords: Seed industry liberalization, cotton seed market, Bt cotton, intellectual property rights

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Chapter 1: Issues

1.1. Introduction and Plan of Study

As subjects of study, seed markets in developing countries have been on the fringes of the literature on agricultural development. The reason is not difficult to seek. For most crops, farmers are themselves the principal source of seed. The task of agricultural development has been seen as primarily one of delivering new technologies to farmers via the public sector, whether in the form of seeds, chemicals and production practices. Thus, issues such as the choice of R&D strategies, the adoption of new technologies by farmers, and the welfare gains from such dissemination have been prominent in the literature. Lipton and Longhurst (1989) is a comprehensive survey of the Green Revolution experience in developing countries.

In recent years, the private sector has become an important supplier of varietal technology in agriculture. Although the trend is most prominent in the developed countries, the retreat of the public sector from seed distribution and seed production is noticeable in developing countries too (Morris, 2002). In developing countries, while a private seed sector has always existed in some form (Pray and Ramaswami, 1991), their working has received much more public attention in recent years. As part of WTO commitments, developing countries have introduced plant breeders rights and product patents in the last decade. The pros and cons of this debate have highlighted the response of private sector to intellectual property rights. While the proponents of intellectual property rights (IPRs) have stressed how it would lead private firms to invest more in agricultural research, the opponents have emphasized how private firms will use the

monopoly power granted by IPRs to the detriment of farmers. This debate has gained additional salience with the advent of plant biotechnology. Unlike conventional plant breeding, the private sector has pioneered the commercialization of plant biotechnology products.

What do these developments mean for small farmers? In particular, would the industry become monopolised and would that lead small farmers to be priced out of the market? Such fears have been expressed by civil society organizations and academics. For instance, a fairly typical comment is that "The Indian seed industry is rapidly moving into a phase of 'corporate control over seeds' with the introduction of transgenic crops" (Shiva, Emani and Jafri, 1999)

In this paper, we study India's cotton seed market to examine the evolution in its market structure and the factors that underlie the changes. The Indian cotton seed market is an excellent case to examine the impact of liberalization, IPRs and biotechnology on market structure. With about $250 million in sales, the Indian cotton seed sector is one of the largest cotton seed markets in the world. It has also been growing rapidly, doubling in value within a short period. While products of public sector breeding traditionally dominated this sector, it is private seed companies that now account for the bulk of value. These dynamics are paralleled by a sea change in the business environment over the last decade and a half. The economic reforms of 1991 lifted barriers to investments by foreign firms as well as by large Indian firms. The introduction of plant breeders' rights through the Plant Variety Protection Act and the commercialization of plant biotechnology products also seem to enhance the advantages of large firms (whether foreign or domestic) with formidable marketing and technological capabilities.

In terms of value, the cotton seeds market is the largest among the crops where the private sector has a presence (other important markets are maize, sorghum and pearl millet). Furthermore, this is the sector that has also seen new products based on genetic engineering. Therefore, it seems reasonable to suppose that this is the sector where changes in market structure are likely to have been the most important.

There is no official published data on the private segment of the seed industry. For this study, we have collected data from a variety of sources: proprietary surveys by market research firms, seed distribution data with government departments of agriculture and our survey of cotton seed dealers in Maharashtra. We have supplemented these by interviews (phone and in person) and email enquiries with seed companies, government officials, agricultural researchers and cotton traders. A complete list of the persons with whom we corresponded is given in the appendix.

The issues outlined above are discussed at greater length in the rest of this chapter. In particular, we discuss the existing literature and the economic context in terms of the current structure of the seed industry, government policy and international trends. Chapter 2 begins with a macro look at the trends in the cotton sector in terms of area and output and production issues specific to cotton. The chapter also sketches a history of public and private sector involvement in cotton hybrids and the factors that have determined their relative importance. Chapter 3 is an account of the trends in cotton seed market and analyzes in particular, the structure of the hybrid seed market in terms of concentration ratios, stability of market shares, and regional variation in market shares. Competition at the retail level and the role of seed dealers and company brands and the market power they command is analyzed in chapter 4. Chapter 5 analyzes the entry

barriers from technology and through its interface with regulatory policies. Chapter 6 gathers the lessons from the earlier chapters and reflects on the wider implications of the study.

1.2 Related literature

The literature on developing country seed markets has mostly emphasized the appropriate roles for the state and the market (for instance, Jafee and Srivastava, 1994; Pal and Tripp, 2002; Pray and Ramaswami, 1991; Singh, Pal and Morris, 1995). Work has also been done on seed regulation and what is appropriate for developing countries (Tripp, 1997).

Investigations of market structure issues are not that many. Tripp and Pal (2000) found that brand recall was weak among pearl millet farmers in Rajasthan suggesting that brand loyalty is not an entry barrier to this market. Pray, Ramaswami and Kelley (2001) showed that during the early 1990s – a period marked by a rapid rise in R&D spending by private seed firms – the market structure became more competitive (as measured by concentration ratios). Shiva and Crompton's (1998) survey of the seed industry in India leads them to the opposite conclusion. They forecast that the seed industry is likely to "coalesce under the control of a few large companies with foreign interests." They argue that the displacement of open-pollinated varieties by hybrid seed, the decline of the public sector, private sector promotions and advertising strategies, plant variety protection laws and transgenic crops are all factors that will make it difficult for small companies to compete in the seed industry.

In an international context, Morris (2002) reviews the impact of globalization on national maize seed industries. While Morris does not define globalization, he considers economic deregulation, domestic market reform, trade liberalization, privatization of State industries and the implementation and enforcement of intellectual property rights as the processes associated with globalization. The outcome of these processes has been an increase in the market share of private firms in markets once dominated by public sector organizations. While Morris acknowledges that a greater role for private firms would have increased the efficiency of the seed system in certain aspects, he also points out that this process has been accompanied by higher seed prices (relative to grain prices) and market concentration. In many countries, the largest three companies control as much as two-thirds of the market.

Morris posits a "life cycle" theory of seed industry development consisting of four stages. The first stage is a subsistence farming system. The second stage sees a formal seed system that is dominated by a public sector. The private sector begins to play a role in the third stage where they do plant breeding work, and produce and distribute seed under quality standards. In the final stage, the industry is dominated by a few large private firms that are largely those that operate globally.[1]

1.3. Structure of the Indian Seed Industry: A Brief Summary

With respect to the products of the seed industry, an important distinction is that between hybrids and open-pollinated varieties. Seeds of varieties can be reproduced for many generations with little deterioration in quality. As a result, beyond the initial

[1] See Pray and Ramaswami (1991) also for dynamics of seed industry development. Compared to this early work, Morris puts greater emphasis on seed industry consolidation as the inevitable and final stage of seed industry development.

purchase, farmers can multiply their own seed. This is not a viable strategy with hybrids because they suffer noticeable declines in yields in subsequent generations. As a result, hybrid seed tend to be repeatedly purchased. Hybrids dominate in cotton and coarse cereals consisting of sorghum, pearl millet and maize. The major cereals of rice and wheat are principally open-pollinated varieties.[2] For these cereal crops, the principal source of seeds is not the seed industry whether private or public but the farmers themselves. Seed saved from the preceding crop supplies nearly 90% of requirements in these crops. In some cases, a large farmer or groups of farmers specialize in growing seeds and supply to neighboring areas. In the case of sorghum, maize and sunflower, the proportions of seed supplied by the commercial seed industry ranges between 25% and 43% (see the estimates of Chopra and Thimmaiah quoted in Shiva and Crompton, 1998).

In terms of organization, the seed industry in India consists of a public and private sector. The public sector consists of the National Seed Corporation, the State Farm Corporation of India and 13 State Seed Corporations. These corporations multiply and market varieties bred by the public sector institutions, i.e., the research institutes financed by the Indian Council for Agricultural Research (ICAR) and the State Agricultural Universities.

There are no firm estimates of the number of private seed firms. Estimates vary from 200 to 500. Private seed firms are heterogeneous with respect to size, research capacity and product segments. Plant breeding research is found in the larger firms. Unlike the public sector, where research is separate from seed production and marketing, these functions are integrated in the private firms. The other striking difference is in

[2] It is much harder to develop hybrids for naturally self-pollinated crops (e.g., rice, wheat) than for cross-pollinated crops (e.g. maize). Rice hybrids have been developed and are these are likely to be important in the future.

product types. The private sector focuses largely on hybrid seed. It is therefore unimportant in the product segments of wheat and rice except as a seller of public varieties and hybrids.[3] On the other hand, the private sector is a major player in the hybrid seed markets of vegetables, sorghum, maize, cotton and pearl millet. In terms of ownership, many of the private firms are closely held and not listed in the stock exchanges although some of the large firms have sold equity to foreign seed companies. Foreign firms maintain a presence through equity stakes in Indian firms, technical alliances or through wholly owned subsidiaries.

Seed firms, whether in the private or public sector, outsource the production of seeds to contract growers. These growers are supplied with the foundation seed that is used to produce commercial seed.

The value of the commercial seed market is estimated to be close to $ 1 billion (Fernandez-Cornejo (2004), Spice (2002), Venugopal (2004)). This makes the Indian seed market among the top ten seed markets in the world. Nonetheless, it is still small relative to the overall global seed market estimated to be worth $25-$30 billion (Fernandez-Cornejo (2004), Spice (2002)). The private sector is estimated to have about 60% of the value of the seed market (Shiva and Crompton, 1998; Spice, 2002). Because the private sector sells high value hybrids, their share in value is greater than their share in volumes. According to one estimate, the top 10 firms, in 2001, controlled about one-third of the market. The rest of the market is supplied by the public sector, smaller firms and the unorganized sector (Spice 2002). The overall picture, after more than a decade of economic reforms, suggests an industry that is fragmented.

[3] However, especially for the large firms, the sale of public varieties and hybrids is not their mainline activity.

Table 1.1 decomposes the purchased seed market into varieties and hybrids for the years 1990/91 and 1998/99. The share of hybrid seed in total value has increased from 32% to 39% while its share in quantity has remained pretty much about the same at around 12-13%. The reason for this can be seen in Table 1.2 that decomposes the hybrid seed segment into proprietary hybrids and public-bred hybrids. Proprietary hybrids are developed and marketed by private firms while public-bred hybrids could be sold by public agencies as well as private firms. Table 1.2 shows a large shift from public-bred hybrids to proprietary hybrids both in quantity and value terms. The share in value of proprietary hybrids is higher than its share in quantity indicating the price premium that proprietary hybrids are able to command in the market place. Together Tables 1.1 and 1.2 indicate the growing role of the private sector in the seed industry.

This is also confirmed by the rapid growth in private sector spending on R&D. According to one estimate, R&D effort (measured by rupee investments, technical personnel, size of experiment stations) in the private sector tripled within a short span of about 8 years from 1988 to 1996. This period was associated with changes in government policy towards the seed industry as well as industry wide economic reforms. The same study concludes that about half of the observed increase in R&D was attributable to the liberalization in government policies that allowed entry into the seed industry by large domestic firms as well as foreign firms (Pray, Ramaswami and Kelley, 2001).

1.4 Government Policy

Prior to 1991, the seed industry was also subject to the policies on industrial licensing and foreign direct investment that applied generally. The seed sector was reserved for the small-scale sector and the entry of foreign firms was tightly regulated. These controls have fallen by the wayside as a consequence of the economy wide reforms of 1991.[4] As a result, there have been no policy barriers to entry into the seed industry by foreign firms and large domestic firms since 1991.

The government regulates the seed industry and the seed trade in various respects. The Seed Act of 1966, the Seeds Control Order of 1983, and the Seeds Policy of 1988 are the major components of policy specific to the industry. The Seed Act of 1966 and the Seeds Control Order of 1983 provide statutory backing to the system of variety release, seed certification and seed testing. Varieties are released after evaluation at multi-location trials for a minimum of three years. Varieties approved are "notified" which is a prerequisite for certification. While all public sector varieties go through this process, it is not mandatory for private varieties.

Certification is a process that certifies that seed is of a specified variety and is of acceptable genetic purity. Usually, seeds are also tested for physical characteristics such as germination capacity, analytical purity and pathogen levels. Certification requires that that the certifying agency has access to the parent lines of the variety. In India, while all public sector varieties are certified, the process is voluntary for private varieties. Often private seed firms do not submit their varieties for certification either because they do not wish to go through the time consuming process of notification or because they have their

[4] The policy change occurred in two steps. In 1987, the seed industry was de-reserved allowing the entry of large firms and foreign firms with equity stake in joint ventures of not more than 40%. In 1991, reforms allowed the entry of firms with majority foreign equity.

own quality control processes. However, uncertified seeds are required to be truthfully labeled listing quality attributes on the label.

The seed control order brings seeds within the scope of the Essential Commodities Act that regulates the marketing of essential items. All seed sales outlets have to be licensed and must observe certain marketing practices such as public display of stocks and prices.

Major changes in this system of regulation are proposed in the National Seeds Policy of 2002 (still awaiting parliamentary approval). Under this policy, variety registration (i.e., notification) will be mandatory for all varieties, new and extant. The evaluation will be done over three seasons of field trials. However, certification will continue to be voluntary. Besides regulating quality, the government has also controlled imports and exports of seed. The Seed Policy of 1988 allowed limited imports of commercial seed. Curbs were removed from imports of seeds of vegetables, flowers and ornamental plants. Seeds of coarse cereals, pulses and oilseeds could be imported for upto two years provided this finally led to technology transfer in the form of parental lines/breeder seed. The proposed new seed policy of 2002 allows imports and exports of seeds of all crops. However, all imported seed is also required to go through the process of registration.

The emphasis on registration in the new seeds policy ties in with the demands of the Plant Variety Protection and Farmer's Rights Act passed in 2001. This Act provides for plant breeder's rights, which requires extant and new plant varieties to be registered on the basis of characteristics relating to novelty, distinctiveness, uniformity and stability.

While the law is on the books, no variety has yet been granted a plant breeders' right. Applications under the Act are yet to be made public (Ramanna, 2005).

The other major change in intellectual property protection has been the change in patent laws. The Trade Related Aspects of Intellectual Property Rights (TRIPs) Agreement came into force in WTO member countries in 1995. This requires member countries to comply with stipulated minimum standards for intellectual property rights protection. As a result, India has amended its Patent Act in 1999, 2002 and 2005. The major impact of these provisions has been to provide product patents in the area of pharmaceuticals. However, the changes have implications for biotechnology innovations as well. The TRIPs agreement requires that patents be provided for micro-organisms. It is unclear, however, to what extent the Indian law is consistent with this provision. It is also not known how the Indian patent office will choose to define micro-organisms. Six patent applications related to cotton have been filed in India till December 2003 (Ramanna, 2005). None have been granted yet.

1.5. The Seed Industry in Developed Countries

The trends manifest in the Indian experience – the rapid growth of the private sector and the gradual displacement of the public sector in certain crops – follows the international experience.

In the United States, private spending for food and agricultural research tripled in real terms between 1960 and 1982. As a result, the private sector invests considerably more in food and agricultural R&D than the government. Furthermore, private research has expanded its range of activities. While earlier most private research in the U.S. was

for farm machinery, new food products and processing methods, the private sector has since developed research capabilities in plant breeding that was once a traditional area of public sector research (Fuglie et.al, 1996). These changes happened over many decades and were the cumulative result of developments in technology and innovations in laws both of which allowed the private sector to reap greater rewards from plant breeding research.

In the United States, seed saved by farmers was the primary source for planting maize (the major field crop) till the early part of the 20th century. Initially, commercial seed suppliers were small family-owned businesses that multiplied and sold seeds of varieties developed in the public sector. In the 1920s, public research was successful in developing high yielding hybrid maize varieties and this created the opportunities for private sector investment in maize breeding (Fernandez-Cornejo, 2004). Later, private investment followed in other crops that were hybridized (e.g., sorghum, sunflower and vegetable crops). For the field crops that were not hybridized, such as soyabean, cotton and wheat, farmer saved seed remained an important competitor to purchased seed for much of the twentieth century. As we shall see, the cotton story in India is similar to the U.S. experience in maize.

The next big development in the U.S. seed industry was the passage of plant breeders' rights in 1970. This was followed by a wave of mergers and acquisitions that created a new structure for the seed industry dominated by large companies (Fernandez-Cornejo, 2004). Interestingly, the consolidation in the seed industry was led by large firms (both U.S. and European) specializing in chemicals and pharmaceuticals such as Ciba-Geigy, Sandoz, Royal Dutch/Shell and Upjohn.

Although some of the large chemical firms have since divested their seed business (e.g., Royal Dutch/Shell, Occidental Petroleum, Upjohn), the lasting legacy of the first wave of consolidation is that in the global seed industry, the seed business is usually a part of a larger agricultural business consisting most often of agro-chemicals. In the 1990s, there was a further wave of consolidation involving pharmaceutical and agricultural businesses. However, in recent years, this trend has weakened and even reversed as these "life sciences" firms have spun off their agricultural business. Monsanto (which has acquired DeKalb Plant Genetics, the international seed business of Cargill and Plant Breeding International and many other smaller firms), Aventis Crop Science (now taken over by Bayer), Syngenta (the agriculture arm of the merger between Novartis and AstraZeneca), Dow Agro Sciences (which acquired Cargill Hybrids) and DuPont (which acquired PioneerHiBred) are some of major input supplying agricultural businesses today. Table 1.3 displays the global seed and pesticide sales of the major multinational firms in 1999. As can be seen, the seed market is much smaller than pesticide market. Therefore, in so far as there are synergies between these two businesses, agro-chemical firms are more likely to have the resources to take over seed companies than the other way around.

1.6 Concluding Remarks

The private seed industry in India is confined to select crops. In particular, it is unimportant in terms of proprietary varieties in the major food crops of rice and wheat (although this could change as rice hybrids become more popular). It is therefore clear

that changes in seed market structure are not relevant to all of agriculture but only to the few select crops that are important to the private sector.

In these crops, our review has shown that there are forces that could conceivably promote consolidation in the seed industry. These are the following:

- The share of hybrids in seed output, value and area cultivated is increasing. And within hybrids, there is a shift towards proprietary hybrids.
- Correspondingly, there has been a many fold increase in R&D spending by the larger seed firms.
- Consolidation in the global seed industry is an old story – its impact would be felt in India given the increasing importance of foreign seed majors in India.
- Genetic engineering technology as exemplified by Bt cotton could be beyond the technical expertise and the financial capability of most seed firms.

Against these factors is the existing picture in which the seed sector is still extremely heterogenous – there are large number of small firms that principally multiply and sell public hybrids and varieties. One estimate is that the top 10 firms control only one third of the seed market – the rest of the market is shared by the public sector, small firms and unorganized players. In the following chapters, we will flesh out in greater detail the structure of the industry for cotton seed.

Table 1.1: Composition of Indian Seed Market, All Crops

Category	1990-91		1998-99	
	Share in Value	Share in Quantity	Share in Value	Share in Quantity
Hybrids	32%	13%	39%	12%
Varieties	68%	87%	61%	88%

Source: Gadwal (2003)

Table 1.2: Composition of Hybrid Seed Market in India, All Crops

Category	1990-91		1998-99	
	Share in Value	Share in Quantity	Share in Value	Share in Quantity
Proprietary Hybrids	43%	25%	72%	57%
Public-bred Hybrids	57%	75%	18%	43%

Source: Gadwal (2003)

Table 1.3: Global seed and pesticide sales of major multinational firms, 1999

Company	Seeds	Pesticides
	Million dollars	
Syngenta	1,173	7030
Bayer	135	4582
Dupont	1835	2309
Monsanto	600	3230
Dow Agrosciences	220	2132

Source: Merril Lynch (2000), as reproduced in Fernandez-Cornejo (2004).

Chapter 2: The Cotton Sector: A Macro Look

2.1 Output and Area

Figures 2.1, 2.2 and 2.3 plot the three year moving averages of all-India output (million tons), area (million hectares) and yield (kgs/hectare) from 1952/53 to 2001/02. The observation for any year is the moving average of that year and the preceding two years. During this period, cotton area increased from about 6 million ha to 9 million ha - an increase of about 50%. At the end of the period, cotton area was about 5% of total gross cropped area. On the other hand, cotton yields during this period more than doubled from a little less than 100 kgs per ha to more than 200 kgs per ha. As a result, output has quadrupled from about 0.5 million tons to about 2 million tons. As can be seen from the figures, output fluctuations have largely mirrored fluctuations in yield.

Although yield growth rather than area expansion has driven cotton output, the yield performance itself does not seem exceptional. Firstly, India's yield levels are still low relative to international levels. China with about half the area produces nearly 1.5 times India's output as its yield is 943 kgs per ha. Average world yields are 550 kg/ha, which is about twice the Indian levels (Alam, 2004). Secondly, the increase in cotton yields does not compare well with the yield performance when compared to the yield increases in rice and wheat during the same period (from 3 to 4.5 times). Finally, as Figure 2.2 shows, cotton yields have been leveling off in the late 1990s. In 2004/05, however, India experienced a record harvest of over 20 million bales of lint cotton as against recent averages of 15 million bales. The harvest in the 2005 season is also expected to be of similar magnitudes. As cotton area has not changed much, the higher production is entirely because of higher yield.

Although the proportion of cotton area that is irrigated has increased from 8% to 35% during the period 1950/51 to 1998/99, cotton is still predominantly grown in the kharif, the rainy season and cultivated under rainfed conditions**.** Table 2.1 displays the distribution of cotton area and yield levels across the major cotton growing states. Maharashtra, AP, Gujarat and Punjab account for 75% of cotton area. Of these, it is only in Punjab that cotton is predominantly grown in irrigated conditions. The Northern states have higher yield levels and irrigation coverage is particularly low in the leading cotton growing state of Maharashtra.

Like in the case of Indian agriculture as a whole, the cotton sector is dominated by small and medium cotton growers. The proportion of large farmers (with land holdings more than 10 hectares) is declining and in 1990/91, they accounted for only 17% of cotton area (Table 2.2). Small and medium growers cultivated the rest of cotton area. It should be noted, however, that compared to food staples such as paddy and wheat, large farmers control more of crop area in cotton.

2.2. Cotton Sector: Pests and Pesticides

The cotton crop is particularly prone to damage from insects and pests. It is attacked by about 150 species of insects (Venugopal, 2004). Among the important pests are jassids (*Amarasca bigutulla*), aphids (*Aphis gossypii*), white fly (*Bemesia tabaci*), spotted bollworm (*Earias vitella*), pink bollworm (*Pectiniphora gossypiella*) and American bollworm (*Helicoverpa armigera*). The Central Institute of Cotton Research estimates that about half of the cotton output is lost to insect pests (Venugopal, 2004, pp 200).

Because of the severity of the pest problem, cotton is the largest market for pesticides. Even though cotton's share in total cultivated area is less than 5%, its share in total pesticide use is between 40 to 45% (Venugopal, 2004, pp 222). In central and southern India, cotton growers typically use 12-15 sprays per season while in Punjab 6-10 sprays are accepted practice. Pesticide use is particularly heavy in irrigated cotton area. In Maharashtra, the leading cotton growing state, more than 70% of irrigated cotton area is treated with pesticides. The corresponding figure for unirrigated area is 60% (Venugopal, 2004). Despite the heavy reliance on pesticides, cotton growers often find them to be ineffective partially or totally. This is because some of the cotton pests such as the American bollworm and white fly have developed resistance to most of the insecticides used to control them (Birthal, Sharma and Kumar, 2000).

2.3. Cotton Sector: Species and Varieties

Research on cotton has emphasized the development of varieties and hybrids with resistance to pests. About 150 varieties and hybrids have been released during the last 50 years. Out of these about 30-40 are under large scale cultivation although about 20 varieties and hybrids account for more than 50% of production (Alam, 2004; Santhanam and Sundaram, 1999).

Asiatic or old world cottons (*Gossypium arboreum* & *G. herbaceum*) and American cottons (*G. hirsutum* and *G. barbadense*) are the four cultivable cotton species. *G. Barbadense* is also known as Egyptian cotton and Asiatic cottons are commonly referred to as *desi* cottons.

In India, *G. Arboreum* and *G. hirsutum* are the principal species that are cultivated. Desi varieties and, in particular, *G. Arboreum* are known for their drought

tolerance and resistance to sucking pests. On the other hand, American cottons usually have long and extra long staple and better spinning potential (higher counts) than desi cottons.

Hybrids have been developed between varieties of the same species and these are called intra-specific hybrids. Across species, 'inter-specific' hybrids have been produced between the American cottons or between the desi cotton varieties. As desi cottons are diploids while American cottons are tetraploids, fertile hybrids with one desi parent and another American parent are not possible.

2.4 Cotton Breeding in the Public and Private Sector: A Short Chronology

India was the first country in the world to commercialize cotton hybrids. The first cotton hybrid H-4, was intra-*hirsutum* (i.e., both parents are *hirsutums*) and was produced by Dr. C. T. Patel in 1970 at the Surat agricultural experiment station of the Gujarat Agricultural University. In 1972 an inter-specific (Female - *hirsutum* X male - *barbadense*) cotton hybrid (Varalakshmi) was released by the University of Agricultural Sciences at Dharwad, Karnataka.

Generally speaking, intra-*hirsutum* hybrids do better than intra-*arboreum* hybrids with respect to fibre quality and yield potential. Note also that inter-specific tetraploid hybrids (cross between *hirsutum* and *barbadenese*) have excellent properties in terms of fibre length and spinning counts. But they usually do poorly in rainfed conditions as the *G. barbadenese* parent in such hybrids is highly prone to moisture stress. Further, they are also susceptible to sucking pests. On the other hand, diploid hybrids (cross between

arboreum and *herbaceum*) are well adapted to drought conditions and are resistant to sucking pests.

A summary history of popular public sector varieties and hybrids is given in Box 2.1. This indicates the breadth of public sector research in developing cotton varieties and hybrids for different states and agro-climatic zones. Public sector research has emphasized high yielding, medium and long staple intra-*hirsutum* hybrids for states in the central zone (Gujarat, Maharashtra and MP), long staple cultivars and inter-specific tetraploids (*hirsutum* x *barbadense*) for states in the south zone (Andhra Pradesh, Karnataka and Tamil Nadu) and inter-specific desi cotton hybrids (*herbaceum* x *arboreum*) for the rainfed areas of Gujarat and Maharashtra. It is also clear that the late 1970s and early 1980s was an active period where the public sector released many location-specific hybrids. These hybrids were in turn based on previous public sector research as one of the parents was usually a local popular cultivar (Bhale, 1999). However, hybrids for states in the north zone (Haryana, Punjab and Rajasthan) were released only in the 1990s.

While India is the largest producer of hybrid cotton seed (Alam, 2004), hybrid cotton production is extremely labour intensive. The male flower had to be separated from the female by tying it up – a process known as hand emasculation. This is very labour intensive. The use of male sterile lines through cytoplasmic male sterility or genetic male sterility has reduced the costs of hybrid seed production. It has also increased purity by avoiding self pollination. The first such hybrid was developed in 1978 under the name Suguna through the use of genetic male sterility. Since then, other public sector hybrids that have been developed through the use of cytoplasmic genetic

male sterility include PKVHy 3 and PKVHy 4. However, most hybrids in India are still produced through the process of hand emasculation.

Box 2.2 sketches a history of private sector hybrids. Private sector hybrids are also called proprietary hybrids and we shall use these two terms inter-changeably. The box confines itself to the hybrids that have been successful. The first private sector cotton hybrid was MECH 11 commercialized by Mahyco in 1979. Mahyco's most successful cotton hybrid was MECH 1 released in 1982. This was developed using the genetic male sterility system. Hybrids from other firms were released in the 1990s. As can be seen from Box 2.2, the number of firms releasing private hybrids picked up in the second half of the 1990s. The successful private sector hybrids are usually intra-*hirsutum* hybrids serving the major markets of Maharashtra, Gujarat and Andhra Pradesh. It is only in recent years, private firms have also released *desi* hybrids and inter-specific long staple hybrid cotton with a *G. Barbadense* parent. It is expected that as extra long fibre begins to command a premium in the cotton market, inter-specific hybrids will become more popular. From the chronologies of public and private sector products, it is easy to see that while the hybrid breeding effort was initiated and sustained in the public sector for the first 20 years, the private sector has made rapid gains since then.

There are several factors that could have played a role in the rapid development of the private sector hybrids in the 1990s. First, this can be seen as a process of technology diffusion and learning. Many of the private sector firms that have their own hybrids today entered the cotton seed business by marketing and producing public bred hybrids.[5] Furthermore, the private sector has relied heavily on retired public sector breeders to lead

[5] Indeed, the leading cotton seed firms continue to market public bred hybrids even though they derive insignificant revenues from it.

their research effort. Second, once the private sector was able to evolve a successful model of hybrid development, production and release, they were also quick to spot the market opportunities left unexploited by the public sector. In particular, the private sector focussed on early duration hybrids with good fibre quality. The early duration hybrids appealed to farmers in rainfed areas anxious to minimize their exposure to weather risk. By comparison, the public sector hybrids were middle to late duration crops. Third, as selling one's own proprietary hybrids offered much greater margins than marketing public bred hybrids, private firms reallocated their resources accordingly. On the other hand, the public sector seed corporations were unable or unwilling to invest in the marketing effort to compete with public bred hybrids.

The 1990s were also the decade of economy wide reforms. In particular, the removal of industrial licensing requirements, small scale industry reservation and restrictions on foreign direct investment significantly eased entry into the seed industry. It is hard, however, to relate these reforms in a direct fashion to the dramatic growth of private hybrids in the cotton seed industry. The major impact that might have been expected would have been the entry of foreign seed companies. While this happened to a limited extent, none of the foreign seed companies that came in were global leaders in cotton. However, it is possible that the threat of such entry might have induced some R&D expenditures by the incumbent firms. Capital market reforms have favourably impacted the access of Indian firms to long term capital at global interest rates (which are significantly lower than in India). However, none of the Indian seed firms have used this route as most of them are still closely held private firms.

2.5 Bt Cotton

Bt cotton is a radical departure from conventional plant breeding. *Bacillus thuringiensis* is a soil borne bacterium toxic to insect pests and safe to higher animals. It widely used as a bacterial insecticide. *Cry* genes from the bacteria determine the action against pests. These have been transferred by genetic engineering techniques to different plants (maize, cotton, vegetables) to confer resistance to pests. Bt cotton offers resistance to an important pest, the American bollworm (*Helicoverpa amigera*), which has developed resistance to all the commonly used insecticides in the country (Kranthi and Kranthi, 2004).

In India, Bt cotton was first released through three hybrids belonging to Mahyco. It contained a Bt gene *cry1Ac* owned by the U.S. firm Monsanto and branded by it as Bollgard. In India, Monsanto has formed a joint venture with Mahyco called Mahyco Monsanto Biotech (MMB), which has the license to use the *cry1Ac* gene.[6] MMB also markets the transgenic Mahyco hybrids. MMB has sub-licensed the Bt gene to other seed firms as well. In 2004, Rasi Seeds offered a transgenic variety while in 2005, Ankur Seeds and Nuziveedu Seeds also received commercialization approval for their Bt cotton hybrids.

Along with these officially approved Bt varieties, there is an illegal Bt hybrid that was first discovered in Gujarat in November 2001. This is Navbharat 151 distributed by Navbharat seeds based in Ahmedabad. It is illegal because it has not received biosafety clearance from the government. Despite prosecution, the plantings of illegal Bt cotton has spread across Gujarat and to other parts of India, notably Punjab.

[6] In addition, Monsanto has taken a 26% equity stake in Mahyco

2.6 Conclusions

In the cotton sector, India's yields lag far behind international levels. India therefore needs quality seeds that can deal with the complex production problems posed by pests and insects. Further, cotton cultivation in the leading cotton growing states is mostly rainfed. Plant breeders have responded to these challenges by producing medium to long staple higher yielding hybrids most suited for Maharashtra, Andhra Pradesh and Gujarat. The research and commercialization effort was initiated and sustained by public sector research for close to two decades. Since the early 1990s, however, the private sector has released many successful hybrids. The rapid rise of the private sector cannot be attributed to any single policy change. Rather it seems to be the result of learning by doing through the process of marketing public-bred hybrids and the market opportunities left unexploited by public-bred hybrids.

Box 2.1: History of Public Sector Breeding in Cotton

- 1968 MCU-5 (*G. Hirsutum*) with a spinning value of good 60's counts yarn
- 1969 Sujatha, the first commercial extra long *G. barbadense* cotton for Tamil Nadu.
- 1970 First commercial hybrid cotton H-4 (intra *hirsutum*)
- 1972 First interspecific hybrid cotton Varalakshmi (*Hirsutum x Barbadense*)
- 1974 Suvin (*G.Barbadense*), superior to Sujatha for spinning 100-120's counts
- 1976 JKHy-1 Long staple hybrid cotton for Madhya Pradesh (intra *hirsutum*)
- 1978 Godavari: Long staple hybrid cotton for Maharashtra (intra *hirsutum*)
- 1980 H6: Long staple hybrid cotton for Gujarat (intra *hirsutum*)
- 1981: PKV Hy-2 Medium staple hybrid cotton for Vidharbha (intra *hirsutum*)
- 1981 DCH-32 an extra long staple hybrid cotton for South Zone* – *hirsutum x barbadense*
- 1982 Superior medium staple Variety LRA 5166 from Coimbatore research station (*hirsutum*) for southern cotton zone and Vidharbha region of Maharashtra
- 1983 NHH44 - High yielding medium-staple hybrid for Marathwada (intra-*hirsutum*)
- 1985 G.Cot DH7: Short staple desi cotton hybrid for Gujarat (*arboreum x herbaceum*)
- 1987: Savita: Extra long staple hybrid cotton for Tamil Nadu and Andhra Pradesh (intra *hirsutum*)
- 1988 G. Cot DH.9 Long staple desi cotton hybrid for Gujarat (*arboreum* x *herbaceum*)
- 1989: H8 Long staple hybrid cotton for Gujarat (intra-*hirsutum*)
- 1994 Hybrid cottons suitable for cotton-wheat cropping sequence released such as `Fateh' for Punjab, 'Dhanalakshmi' for Haryana and "Maruvikas" for Rajasthan – all medium staple intra – *hirsutum*.
- 1995 DHB-105, a suitable replacement for DCH-32 - *hirsutum x barbadense*
- 1995 H10, Long staple intra-hirsutum hybrid cotton for Gujarat
- 1997 Om Shankar, medium staple early maturing hybrid cotton adaptable for the entire North- Zone* tract (intra *hirsutum*)

*South Zone: Tamil Nadu, Andhra Pradesh, Karnataka
*North Zone: Punjab, Haryana, Rajasthan

Source: Collected from Bhale (1999), Santhanam and Sundaram (1999) and http://www.ikisan.com/links/ap_cottonHybrid%20Cotton.shtml

Box 2.2: Chronology of Private Sector Hybrids

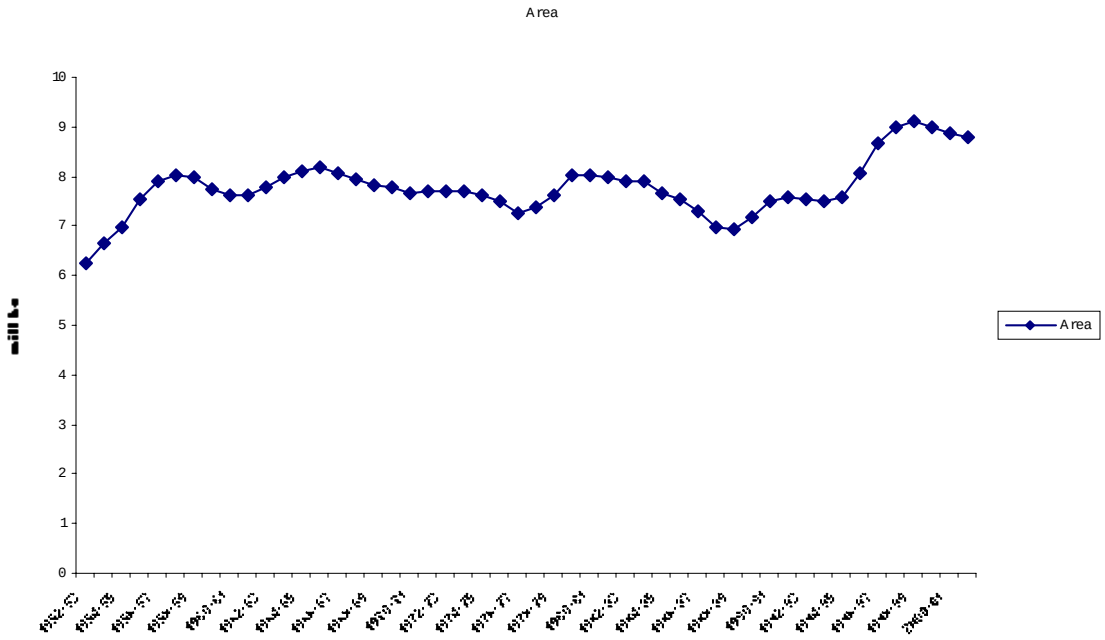
- 1979: MECH 11 from Mahyco- medium to long staple intra-*hirsutum* hybrid for Maharashtra and Andhra Pradesh.
- 1982: Mech 1 from Mahyco – intra-*hirsutum* long staple hybrid for Central* and South Zone.
- 1992: RCH.2 from Raasi Seeds – long staple intra – *hirsutum* hybrid for Tamil Nadu, Andhra Pradesh and Maharashtra
- 1993: Ankur 651 from Ankur Seeds – long staple intra- *hirsutum* hybrid for Maharashtra.
- 1995: Vikram 5 from Vikram Seeds – long staple intra-hirsutum hybrid for Gujarat
- 1996: Ajeet 11 for Maharashtra and Ajeet 33 for Central Zone from Ajeet Seeds: both medium to long staple intra-hirsutum hybrids.
- 1997: Paras Brahma from Hindustan Lever (taken over by Emergent Genetics) – long staple intra-*hirsutum* hybrid for Andhra Pradesh and Maharahstra.
- 1998: Maruti 9632 from Maruti Seeds – medium to long staple intra-*hirsutum* hybrid for central zone states.
- 1998: Bunny from Nuziveedu Seeds – long staple, medium duration intra-*hirsutum* hybrid with large boll size for central and south zone states
- 1999: Sri Tulasi (TCHH-4) from Tulasi Seeds, long staple intra-hirsutum hybrid for Andhra Pradesh, Maharashtra
- 2000: Dhanno from ProAgro, long staple intra- *hirsutum* hybrid.
- 2001: Navbharat 151 from Navbharat Seeds, for Gujarat.
- 2002: Bt hybrids, MECH 12, MECH162 and MECH 184 from Mahyco approved for all regions except North Zone.
- 2002: Durga from JK Seeds, extra long intra-hirsutum hybrid for Andhra Pradesh
- 2002: Kaveri 119, Kaveri 135, Kaveri 705 – long and extra long intra-*hirsutum* hybrids for Andhra Pradesh
- 2002: Sigma from Vibha Seeds - extra long intra-*hirsutum* hybrid for Maharashtra
- 2004: Bt hybrid RCH2 from Rasi Seeds approved for central and southern region

*Central Zone: Gujarat, Maharashtra, Chattisgarh and Madhya Pradesh

Source: Our interviews with seed companies

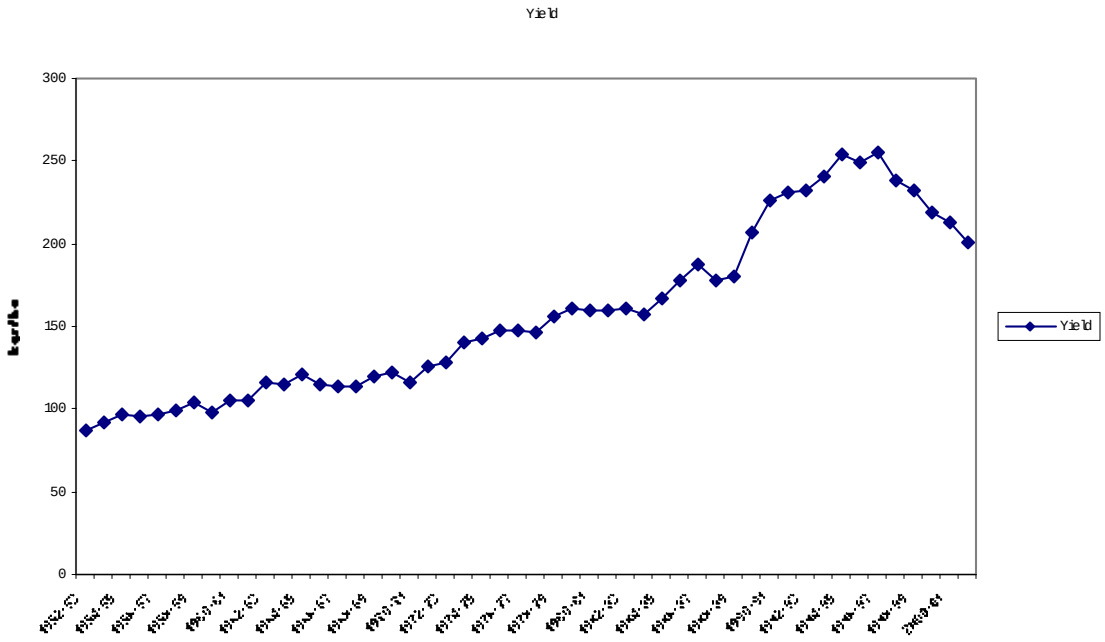
Figure 2.1: Area under Cotton, 1950/51-2002/03

Million Hectares



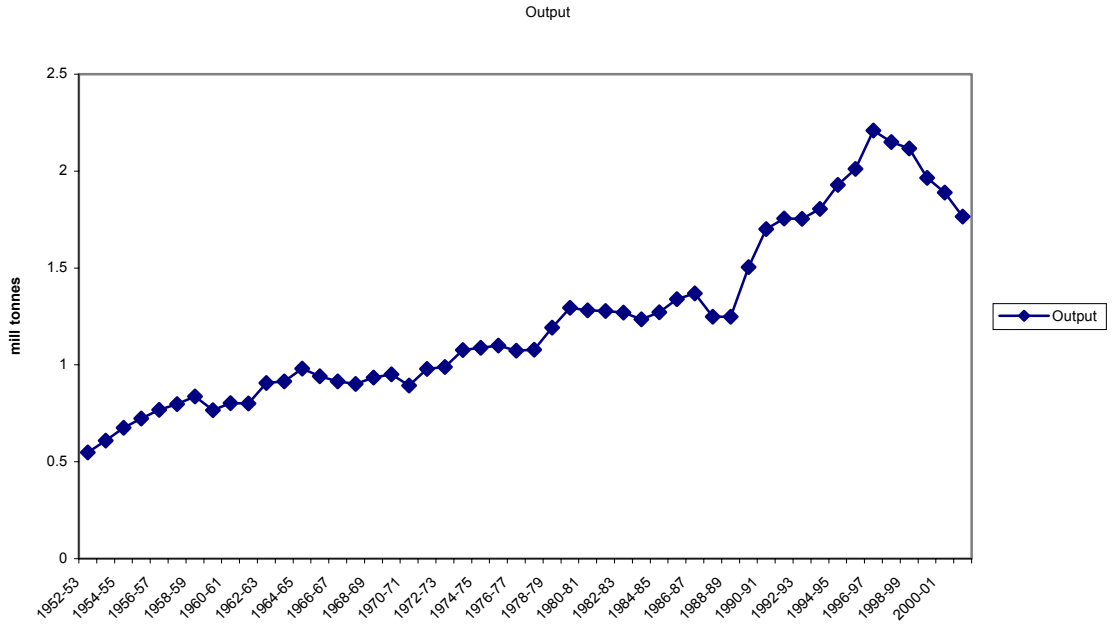
Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

Figure 2.2: Cotton Yields (Kgs/Ha), 1950/51-2002/03



Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

Figure 2.3: Cotton Output, 1950/51-2002/03
Million tonnes



Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

Table 2.1: Distribution of Cotton Area and Output across States:

Averaged across 2000/01 & 2001/02

State	Area (mill. Ha)	% of total area	Production (mill. bales of 170 kgs each)	% of total production	Cumulative %	Yield (kgs/ha)	% of cotton area irrigated
Maharashtra	3.09	34.6	2.25	22.9	22.9	123.8	4.1
Andhra Pradesh	1.15	12.9	1.77	18.0	40.9	261.6	18.1
Gujarat	1.69	18.9	1.43	14.5	55.4	143.9	42.4
Punjab	0.54	6.2	1.26	12.8	68.2	396.7	99.7
Haryana	0.6	6.7	1.05	10.7	78.9	297.5	99.6
Karnataka	0.58	6.5	0.79	8.0	86.9	231.6	13.8
Madhya Pradesh	0.52	5.8	0.32	3.3	90.2	104.6	40.0
Tamil Nadu	0.18	2.0	0.33	3.4	93.6	311. 7	34.9
Rajasthan	0.51	5.7	0.55	5.6	99.2	183.3	97.9
Others	0.06	0.7	0.09	0.8	100.0	--	---
All India	8.92	100.0	9.84	100.0	--	187.5	35.2

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

Table 2.2: Distribution of Cotton Area (%) by Farm Size

	Small & Marginal Farmers (landholding < 2 ha)	Medium Farmers (landholding between 2 & 10 ha)	Large Farmers (landholding > 10 ha)
1980-81	11.98	60.32	27.69
1990-91	21.06	61.61	17.33

Source: R. S. Deshpande et. al (2004), pp 240

Chapter 3: Structure of the Cotton Seed Market

3.1 Definitions and Data Sources

In the developed countries, waves of mergers and acquisitions have pretty much extinguished firms that develop, produce and sell seeds as their only activity. The industry is characterized by a few `mega-firms' with combined capabilities in biotechnology, agrochemicals, and seeds (Pingali and Traxler, 2002). Furthermore, in expanding their biotechnology activities to the developing world, the mega-firms have joined hands with national seed companies (through acquisition or joint ventures) in order to backcross their gene constructs with locally adapted germplasm.

It therefore follows that in developing countries, seed prices and market power depend on the competition within the seed market as well as the competition within the technology market that prices the technology transfer from developed to developing countries. In this chapter, we are solely concerned with the competition in the seed market. The technology market is considered in chapter 5.

The source for our information on market sales and volume comes from a proprietary survey of cotton growers (called `Cotton Crop Track') done by Francis Kanoi Agri-Inputs Marketing Research (2005). The first of these surveys was done in 1996/97. The survey is done every two years and the most recent survey was in 2004/05.

The survey uses a stratified design where the strata are districts. The sample size per district is fixed according to the cotton growing area. The farmers are sampled by a clustering procedure. First, villages are randomly selected from a census listing. Within the selected village, 20 cotton growers are randomly picked. In 2004/05, the survey covered 13256 cotton growers in 1002 villages of 44 districts.

3.2 Seed Replacement Rates

Cotton is one of the most important crops for the private seed industry in India. Unlike the major cereal crops, a large proportion of cotton area is planted with purchased seed. For hybrids, whether private or public, 100% of the seed used is purchased. Even for varieties, the seed replacement rate is high in most of the states. This is shown in Table 3.1 for 2002/03 and 2004/05. As can be seen, the ratio of seed purchased to the quantity of seed used exceeds 90% in Andhra Pradesh, Maharashtra and Tamil Nadu.

3.3 Composition of Seed Market

Table 3.2 shows the size of the cotton seed market by area, volume and value.[7] Note the volume figures refer to the seed purchased and not the quantity of seed used. The area under cotton has fluctuated between 1996/97 and 2004/05 without much of a trend. On the other hand, the volume of seeds sold has fallen sharply. The explanation lies in the substitution of varieties and public hybrids by private hybrids that have a lower seeding rate. This is elaborated below.

The value of the seed market, in nominal terms, remained stagnant between 1996/97 and 2002/03 but almost doubled in 2004/05. In 2004/05, the total seed market was worth Rs. 11500 million which is about $250 million. As the Indian seed market is estimated to be worth $1 billion, the cotton seed market is a fourth of the total market for

[7] In the survey data, information about the quantity of seeds of varieties purchased in Gujarat is not available for the year 2004/05 which makes the total volume and value figures for 2004/05 noncomparable with the earlier years. To get around this problem, we impute a value to the missing figure. The procedure is to use the information about the quantity of seeds of varieties used in Gujarat (which is available) and the seed replacement rate for 2002/03. Note that as the seed replacement rates for other states have not fluctuated much between 2002/03 and 2004/05, the errors from this procedure are not likely to be large. This is then used along with the quantity of seed sold in other states to get the aggregate quantity of seed sales of varieties. Similarly, the value figures for 2004/05 are also adjusted to include Gujarat using a price of Rs. 200 per kg for variety seed (the average price of such seed in neighbouring states.

seeds in India. When deflated by the index of wholesale prices for all commodities, the cotton seed market declines in value until 2002/03 and then increases by 50% in 2004/05. When deflated by an index of cotton prices, the rise in the last year is even sharper. During this period, between endpoints, cotton prices have risen by less than 20% (with a big spike in between in 2003/04). Seed values have thus risen faster (but only for the last year) than output prices.

Figure 3.1 is a bar chart of the composition of cotton area in terms of the percentage area under proprietary (i.e., private) hybrids, public hybrids and varieties. The percentage of area under varieties and especially public hybrids has fallen consistently over these years. Proprietary (or private) hybrids that used to be the least important in 1996/97 have emerged as the most popular seed source in 2004/05. In 2004/05, proprietary hybrids accounted for 5 million hectares (12.5 million acres), public hybrids for nearly 1 million hectares (2.3 million acres) and varieties for another 2.6 million hectares (6.4 million acres).

Figure 3.2 is the analogous chart for volume of seed sold. Note that the trends in composition of area are reflected here but in a very weak form. This is because, despite their decline in area, varieties remain dominant in volume because of their higher seeding rate. Finally, Figure 3.3 that plots the trends in the composition of the seed market by value confirms the dramatic rise of proprietary hybrids. This figure also shows that the large decline has been that of public hybrids which accounted for 55% of the value of the cotton seed market in 1996/97.

As noted earlier, while overall cotton area has remained pretty much stagnant, the volume of cotton seed has fallen by nearly 50%. The explanation for this is the

substitution of public hybrids and varieties by private hybrids as the seeding rate is the lowest for private hybrids. In Table 3.3, we use the area and volume figures of varieties, public and private hybrids to calculate the implied seeding rate per hectare. Note that as the seeding rate is computed on the basis of purchased seed and not on the basis of used seed, the implied seeding rates calculated in Table 3.3 underestimate the true seed rates for varieties. Table 3.3 shows that the seeding rate for private hybrids fluctuates between 1.14 and 1.68 kgs per ha while that for public hybrids varies between 2.01 and 2.66 kgs per ha. The seeding rate for varieties is in the range from 9 to 11 kgs per ha.

To sum up, we observe a big shift towards proprietary hybrids in the area wise composition of the seed market. The volume figures also display the shift but the movement is muted because of the lower seed rate of proprietary hybrids. Despite this, the shifts in terms of value are dramatic. Proprietary hybrids account for most of the seed market. Both public hybrids and varieties have declined – however, it is public hybrids that have declined drastically. This development means a reduced presence in the seed market for not only the public sector but also the smaller seed companies that have traditionally depended on sales of public bred hybrids and varieties.

It is also clear that the segment that the private sector occupies is the dominant one. Currently, hybrid seeds (public + private) occupy 70% of cotton area i.e., about 6 million hectares (nearly 15 million acres) and about 95% of the value of the cotton seed market. Thus, market structure issues are relevant to this industry. It would not have been so if the seed market was dominated by varieties.

3.4 The Contribution of Bt Cotton Seeds to Seed Market Growth

Bt cotton seeds were approved for commercial release in 2002 kharif. However, the adoption was negligible that year (100,000 acres) and is not captured by the Francis Kanoi survey data. By 2004/05, the adoption had spread to 3 million acres (legal and illegal Bt seeds). How has this affected the size of the proprietary seed market?

Between 2002 and 2004 kharif season, the volume of proprietary hybrids increased by 81%. Excluding Bt cotton, the volume of proprietary hybrids increased by 42%. Thus about half of the increase in volume of proprietary hybrid seed is because of Bt and the remainder is because of other non-Bt proprietary hybrids. Bt has hastened the shift towards proprietary hybrids.

As Bt seeds are more expensive than non-Bt hybrids, the contribution of Bt to the growth in value would be greater. Between 2002 and 2004, the value of proprietary seeds sold jumped up by an astonishing 141%. In 2004, legal and illegal Bt seeds cost about Rs. 3500 per kg and Rs. 2400 per kg respectively (see Table 3.14 discussed later). If their adoption displaces other proprietary hybrids (which cost nearly Rs. 1000 per kg), the net value gained due to legal and illegal Bt is Rs. 2500 and Rs. 1400 per kg respectively. Multiplying it by the Bt seeds sold in 2004/05, the overall value gain because of Bt seeds (legal & illegal) is Rs. 3026 million that amounts to 52% of the overall increase in the value of proprietary seeds between 2002/03 and 2004/05. It is clear therefore that, without the higher priced Bt cotton seeds, the seed market would have grown at a modest rate.

What of the future? As adoption of Bt cotton seeds spreads, the value of the cotton seed market will rise. Suppose, and this is a conservative projection, the area

under Bt seeds were to double from 3 million to 6 million acres and also suppose that the increment in area is evenly split between legal and illegal seeds and that it displaces an equivalent area under non-Bt proprietary hybrids.[8] Assuming a seeding rate of 450 grams of seed per acre, the value of legal Bt, illegal Bt and nonBt proprietary hybrid seed per acre is Rs. 1575, Rs. 1080 and Rs. 450 per acre. This will then result in an additional income of Rs. 2600 million (US $56 million) to the cotton seed industry – an increase in the size of cotton seed market by 22% (from Rs. 11500 million). As this increase in value will accrue largely to the owners of technology, could it become a force for consolidation?

3.5 Statewise Seed Markets

Tables 3.4 to 3.12 display the composition of the seed market in terms of area for the major cotton growing states. (We also have composition of the seed market by volume – we do not report it because the trends are similar. Also because of the different seeding rates between hybrids and varieties, the composition in terms of volume can blur the shifts in area as was seen in national data). The top 3 cotton growing states are Maharashtra, Andhra Pradesh and Gujarat. Between them these states account for 6 million ha of the 8.6 million ha of total cotton area, i.e., nearly 71% of the cotton area is in these states. This indicates the importance of these states for the cotton seed suppliers.

Over time, cotton area has fluctuated but at a stagnant level in Maharashtra and AP while it has increased in Gujarat. Among the remainder states, cotton area has declined in all of them except MP where it has increased slightly. Cotton area has

[8] As we report in Chapter 5, industry estimates for the 2005 season suggest that the area under Bt hybrids is in the range of 8-9 million acres.

consistently declined in every year in Rajasthan and Karnataka. Except for these states, cotton area was higher in 2004/05 than in 2002/03 in all other states. Indeed, if the last year is ignored, we observe a picture of declining cotton area in most states. Overall, therefore, cotton is a crop that is either stagnant or declining. Whether Bt will reverse the decline remains to be seen.

The data indicate that in the last year of the survey, 2004/05, Haryana, Rajasthan and TN were predominantly variety growing states. Punjab, Gujarat and Karnataka were states where varieties and hybrids coexist while hybrids dominate in AP, Maharashtra and MP. For the period 1996/97 to 2004/05, the importance of varieties has declined in every state except Karnataka and Gujarat. The decline in the share of varieties in cotton area has been particularly large in Punjab that used to be dominated by them. Varieties have also lost ground in Maharashtra and AP. In Gujarat, the proportion of cotton area under varieties fluctuates at levels less than 20% but suddenly jumps up to 44% in 2004/05. This figure seems very doubtful. It is probably that at least some area under illegal Bt cotton varieties is being reported as varieties. Cotton area in Rajasthan and Haryana remains predominantly varieties.

Mirroring the national data, proprietary hybrids have gained in all states and especially so in the major cotton growing states of AP, Maharashtra, Gujarat and Punjab. Correspondingly, public hybrids have declined in all states.

3.6 Market Shares

Within the seed industry, the size of the proprietary seed market as well as a company's turnover is calculated in terms of number of packets sold where the size of a packet is 450 grams. A packet is supposed to be sufficient to seed an acre of land

although this is a rule of thumb rather than an exact formula that is followed by all cotton growers.[9] The seeding rate per acre in the Francis Kanoi survey has varied from 450 grams per acre to 570 grams per acre over different years. Using the industry rule of thumb, the size of the proprietary seed market in 2004/05 is 12.5 million packets while the Francis Kanoi survey pegs it closer to 15 million packets.

Industry observers as well as the Francis Kanoi survey agree that the turnover of the top ranked firm would not exceed 3 million packets. At the lower end, a firm with sales of more than 0.1 million packets usually sells it a branded product with significant investments in sales promotion activities although there are a few firms with branded products that fail to reach this threshold. In 2004/05, the top 5 firms had an average volume of 1.7 million packets while the corresponding figure for the bottom 5 firms (of the top 10) was 0.6 million packets.

At the lowest end are small seed firms with sales between 15000 and 30000 packets with little or no brand visibility. According to the Francis Kanoi survey, such firms account for about 15% of the market (by volume), which corresponds, well with industry estimates of 15-20%.[10]

In the earlier sections, we saw that higher priced proprietary hybrid seed have been displacing lower priced public hybrids. This has contributed to the growth in the value of the seed market. It has also meant that the countervailing power of the public sector has declined. This would reduce choices for growers and increase market power of the private firms if the proprietary seed market is concentrated.

[9] Public hybrids are sold in packets of 750 grams.
[10] In the Francis Kanoi survey, such nonbranded seeds are not separately enumerated. Their market share is derived as the difference between the total market size and the share of the branded seeds.

Figure 3.4 displays the market shares (by volume) of the top 5 firms (5-firm concentration ratio) in the proprietary hybrid seed market. Figure 3.5 displays the 5-firm Herfindahl index of concentration, which is regarded as a better measure because it squares the market shares before adding it up and therefore gives a higher weight to the larger firms. Because of lack of suitable data, the market shares and Herfindahl index can be computed on the basis of firm shares of volume of seed sold rather than on the basis of value of seed sold. However, this is not misleading as long as there is not much variation in the prices of proprietary seed of different firms.[11] The most serious violation of this condition occurs in 2004/05 when there is significant adoption of Bt seeds that are priced much higher than nonBt hybrids. To correct for this, we normalize with respect to nonBt hybrids. As a later table (3.14) will show, legal Bt seed is about 3.5 times more expensive than a nonBt hybrid. The legal Bt component of a firm's seed sales is multiplied by 3.5 to obtain the equivalent amount of nonBt seeds that would generate the same revenue. The overall volume figures are similarly adjusted. Illegal Bt seeds are about 2.4 times more expensive than nonBt proprietary hybrids. Therefore, we also make an adjustment for the volume of illegal Bt seeds along the lines of legal Bt seeds.

The theoretical justification for the Herfindahl index, or for that matter, any other concentration index, is weak. In particular, theory does not predict a systematic correlation between the Herfindahl index and economic variables of interest such as industry profitability or overall welfare except under limited conditions. However, the Herfindahl index is widely used in applied studies because of its value as a measure of competitiveness. According to the United States' Department of Justice merger guidelines for anti-trust action, a market with a Herfindahl index below 1000 is regarded

[11] As chapter 3 shows, seed prices of proprietary hybrids are pegged around the same rate.

as "unconcentrated," between 1000 and 1800 as "moderately concentrated," and above 1800 as "highly concentrated."

In the proprietary seed market, the 5-firm concentration ratio declines by 25 percentage points from 84% to 59%. The 5-firm Herfindahl index declines quite sharply from 2087 in 1996/97 to 870 in 2004/05. It should be remembered that the proprietary seed market was a small part of the hybrid seed market in 1996/97 and therefore the relatively high level of concentration in 1996/97 relates to a still young and incipient market. By 2004/05, when the proprietary market is several times larger and dominates the hybrid seed market, the Herfindahl index drops to below 1000 indicating a competitive market structure.

In Table 3.13, we compare the seed sales of the top 5 firms and of the bottom 5 firms (in the top 10 ranking). The figures are normalised with respect to the seed sales of the bottom 5 firms in 1996/97. While sales of the top 5 firms increased by nearly 4 times during this period, sales of the bottom 5 firms grew at twice the pace and increased by nearly 8 times. Thus, in a growing hybrid market, the smaller firms have closed some of the gap between them and the market leaders.

As the proprietary hybrid market expanded, it also induced entry from several players and this reduced the market share of the leaders. To see this, consider the number of firms each year that have sales greater than or equal to the sales of the firm ranked fifth in 1996/97. By definition, this number is 5 in 1996/97. It increases to 6 in 1998/99, 7 in 2000/01, 9 in 2002/03 and 12 in 2004/05.

For whatever reason, public hybrids have been unable to compete with proprietary hybrids. This is confirmed by an analysis of the price gap between public hybrid seed and private hybrid seed (excluding Bt cotton seed) shown in Table 3.14.[12]

These computations show that the price gap is increasing with time. To take account of the different seeding rates of proprietary hybrids (1.4 kgs per ha) and public hybrids (3.2 kgs per ha), we also work out the cost of using seed per hectare. The cost difference between proprietary non Bt and public hybrids rises from Rs. –9 per ha to Rs. 473 per ha. Despite this, proprietary hybrids have increased their market share at the expense of public hybrids. The power of proprietary hybrids to charge a mark-up over public hybrids could arise from a perception of quality difference or it could reflect a retreat of the public sector in terms of supply of its hybrids. Our survey of cotton seed dealers in Maharashtra (described in the next chapter) show that popular public-bred hybrids are produced and sold by a number of private firms (including the ones with proprietary brands). This would seem to suggest that private firms would be quick to seize upon any unmet demand for public hybrids.

3.7 Market Leaders and Changes over Time: Churn

In this section, we consider the stability of market shares over time. To do this, we do two kinds of data analysis. First, we consider the top 8 firms (according to seed sales in tons adjusted for differential prices between Bt and nonBt seeds) in 1996/97 and

[12] For 2002/03, the survey does not give the average price of proprietary hybrid seed excluding Bt cotton seed but for proprietary hybrids as a whole. The break-up can be obtained by more computations. As Bt cotton was adopted on 100,000 acres in 2002/03, this results in Bt value of Rs. 1600 million and in a volume of 45 tonnes. Deducting these from the total volume and value of proprietary seeds, we get an average price of Rs. 725 per kg for proprietary hybrids. For 2004/05, the survey reports separate volume and value figures for proprietary Bt and nonBt hybrids.

trace their ranking (in terms of market shares). We examine how many firms of this initial set remain in the top 8 set in 2004/05. This would show whether market leadership once attained endures or not. Second, we consider the set of top 8 firms in 2004/05 and then go backwards to see their market rankings in previous years to see how many of these firms constituted the top 8 set in 1996/97. This would tell us whether entry takes places into the top bracket of firms. Tables 3.16 and 3.17 display the outcome of this analysis.

Of the set of 8 firms that had the highest market shares in 1996/97, four firms had lost enough of their market sales to fall out of the top 8 list by 2004/05. In the reverse direction, four firms that were in the set of top 8 in 2004/05 did not figure in the similar list for 1996/97. The tables also report a summary measure of stability. Let R_{it} be the ranking in year t of the ith firm belonging to the initial set (whether the top 8 of 1996/97 or the top 8 of 2004/05). Clearly, in any particular year, R_i can take values ranging from 1 to 8 if firm i remains in the top 8 set. If firm i drops out of the top 8 set, we assign it a ranking of 9. This, as we shall see, biases the measures in favour of stability. Then the stability measure in year t is

$$\Psi_t^1 = \sum_{i=1}^{n} [8 - (R_{it} - 1)] \qquad (1)$$

Thus, a firm ranked 1 receives a weight of 8, a firm ranked 2 receives a weight of 7 and so on. Note that a firm that falls out of the initial set receives a weight of zero. In the initial year, the stability measure is just a sum of ranks, which is 36. If all the firms drop out of the initial set, the measure is zero.

The measure weights the top ranks more than the bottom ranks. Thus, for instance, if in any year the initial set does not contain the ranks 6, 7 and 8, then the

stability measure is 30. On the other hand, if the initial set does not contain the ranks 1, 2 and 3 then the stability measure drops to 15. Thus, the measure is more sensitive to the loss of top ranks than to the bottom ranks.

As mentioned earlier, we assign a rank of 9 (and hence a weight of zero) to firms that drop out of the initial set. Ideally, we should be assigning the observed rank (which could be greater than 9) to a firm that drops out. In such a case, the weight to a drop out firm in (1) could be negative and the stability measure will be more sensitive to big losses and gains of market share. The problem is that for a firm that vaults into the top 8, its ranking in the earlier years (out of the top 8 list) may not be recorded either because it did not exist or because its market share was too small. Similar is the case with firms that experience big losses of market share. One way to deal with this issue is that for firms that have too small a market share for it to be recorded in the data, we assign a rank to them such that they have the lowest ranked market share. For instance, if in a particular year, the data records the market shares of 12 firms and if a firm belonging to the initial top 8 set does not figure among these 12 firms, then it would be given a rank of 13. Let us call such a stability measure Ψ^2.

Both the stability measures are reported in tables 3.16 and 3.17. The set of market leaders in 1996/97 pretty much collapsed in 2004/05. Several of the firms in this set experience large drops in market share especially in 2004/05. In the other direction, the stability is much greater although even here there is some flux because of new entry. The greater stability here suggests that the new firms that entered the top 8 in 2004/05 were on the fringes of this set in earlier years. However, the greater stability here is, however, somewhat of an artifice of the data. This is because two of the firms that were in the top

8 in 2004/05 (Navbharat, Tulasi) were too small to have recorded market shares in the earlier years. Further, as the number of firms with recorded market shares was smaller in the earlier years, they got assigned a rank that is higher than what would have happened to firms that lost market shares more recently.

Overall then, firms can lose their market shares and new firms can enter the ranks of top firms in a short time. Underlying the rapid flux, there is the dynamics posed by Bt. This has accelerated the rapid decline of some firms like Vikram and been the factor responsible for entry of Navbharat and the consolidation of Mahyco and Rasi in the top ranks.

3.8 Regional Variation in Market shares: The Hybrid Seed Market

Table 3.18 displays the distribution of hybrid seed (public + proprietary) sales across the different states. The big markets for hybrid seed are Maharashtra (43 to 49%), Gujarat (16 to 22%), AP (13 to 19%), MP (10%). These states account for 85-94% of the hybrid seed market. Thus, private players that are successful in these major markets will be among the market leaders nationally. In recent years, hybrid cotton has made rapid headway in Punjab and in futures this could also be a major market for hybrid seed.

Table 3.19 displays the 5-firm Herfindahl index for the major hybrid seed markets over the period 1996/97 to 2004/05. Like the computations of section 3.6 and 3.7, the market shares are based on volumes adjusted for the higher price of Bt seeds. In both Maharashtra and Andhra Pradesh, the proprietary seed markets have evolved from high degrees of concentration to near competitive market structures. Gujarat, on the other hand, has always been characterized by high degrees of concentration. In the pre-Bt period, the products of Vikram Seeds (Vikram 5 and Vikram 9) dominated the market

leaving little space for others. But in the post-Bt period, these hybrids were completely eclipsed by Navbharat 151 (the illegal Bt) and the Mahyco Bt hybrids. In Madhya Pradesh, market concentration declined monotonically from 1996/97 to 2002/03. However, concentration has increased sharply in 2004/05. The reason once again is because of a shift in farmer preference towards Bt hybrids as a result of which Mahyco Bt hybrids have gained a dominant market share. Although Andhra Pradesh and Maharashtra have also seen swings in farmer demand towards Bt hybrids, the shift has been more gradual. Industry reports for 2005/06 indicate a pronounced move towards Bt hybrids even in these states. However, impacts for concentration are unclear because legal Bt hybrids in the 2005 season were available from 4 sources: Mahyco, Rasi, Ankur and Nuziveedu Seeds.

The firms that figure in the top 5 in each of the 4 states is an indication of the number of firms that have successful brands. This is important because if a regional market is currently concentrated, it would attract entry and the list of potential entrants can be spotted by looking at the firms that are market leaders in other regions. In the extreme case where market leaders (i.e., the top 5 firms) do not overlap across states, there could be 20 distinct firms across the 4 states. And in the other extreme case, where the same firms dominate the industry in all the states, only 5 firms would figure in the top 5 list in each and every state.

In 2004/05, there were 9 firms across the 5 states that figure in the top 5 list in 2004/05. The same number was 8 in 1996/97 when the hybrid market was much smaller. The 2004/05 list consists of Mahyco, Nuziveedu Seeds, Rasi Seeds, Ankur Seeds, Emergent Genetics, Navbharat Seeds, JK Seeds, Syngenta and Tulasi Seeds. Other firms

which are on the fringes of this list and strong in regional pockets (especially in Maharashtra and Andhra Pradesh) include Krishidhan, Pravardhan, Vibha Seeds, Nath Seeds, Ganga Kaveri and Prabhat.[13] Thus, there seems to be a minimum of 15 firms with recognizable brands of proprietary seeds.

3.9 Mergers and Foreign Direct Investment

Unlike the developed country experience, India has not seen significant merger activity between seed companies and agro-chemical firms. SPIC and Rallis India are two firms that have interests in both seeds and agro-chemicals. However, neither of them are important in the cotton seed sector.

Nor are there home grown "life sciences" firms that have invested in the agricultural end of the business. Overall the Indian biotech industry had revenues in 2004/05 of about $1 billion or Rs. 47450 million of which agri-biotech (principally Bt cotton) is less than 10% at around Rs. 3000 million. The largest biotech firm, Biocon Ltd, which is Indian owned had revenues more than twice of all agri-biotech. Thus, the Indian biotech firms have the size to enter the cotton seed industry. However, they have chosen not to do so.

As for foreign firms, the two significant ones with a presence in the cotton seed industry (and agro-chemicals) are Monsanto and Syngenta.[14] Syngenta operates through a wholly owned subsidiary that used to be called Sandoz. But when the parent company based in Switzerland merged with Ciba-Geigy and then again with AstraZeneca, the agricultural spinoff became Syngenta. Monsanto has a presence through its equity stake with Mahyco and its joint venture with Mahyco in marketing activities. It is also the

[13] The list is indicative and not meant to be exhaustive.
[14] According to press reports, Delta & Pineland, the cotton seed major from U.S. is due to enter the Indian market.

owner of the cotton business of Emergent Genetics that acquired Mahendra Hybrid Seeds (with the Mahalaxmi brand) and Paras Extra Growth Ltd (with Paras Brahma and Paras Krishna brands from Hindustan Lever). Bayer Crop Science is active in India through Pro-Agro; its cotton hybrid sold under the brand name "Dhanno" (intra-*hirsutum* long staple) is not yet a market leader in the major hybrid growing states.

Dupont's activities in India includes both the agro-chemical business and the seed business through Pioneer but the seed activity does not include a cotton component. Dupont markets its brand Avaunt for controlling major Lepidoptera pests in cotton & vegetables and is presumably adversely affected by the adoption of Bt cotton.

3.10 Conclusions

Three phases have marked the growth of the hybrid cotton seed market in India. The first phase, beginning in the early 1970s and upto the early 1990s, was the period of public sector hybrids. The second phase ending around 2003, was when the proprietary seed market established itself. The third phase which is just beginning and which has yet to play out, is one where the market is being shaped by transgenic cotton.

The proprietary seed market was dominated by a few firms in its early days. However, as the hybrid seed market consisted largely of public hybrids, market power was unlikely to have been large. As proprietary seed market grew, concentration fell and by widely used criteria, the proprietary seed market is highly competitive in 2004/05. Furthermore, we saw that the set of market leaders has changed over the period 1996/97 to 2004/05 because of entry and exit from this set. When market leadership is examined regionally, we see that over the four principal markets, there are as many as 9 firms that are among the top 5 firms in each of these markets.

Therefore, whether judged by concentration indices, the entry and exit among market leaders or regional variation in market leadership, the evidence is solidly in favour of the hypothesis that the hybrid seed market is competitive. The market may not satisfy the text book definition of competition as it is likely some of the firms possess market power because of differentiated products. However, the market is highly contested and it therefore seems unlikely that monopoly profits are being earned. For an overall assessment, though, we would need to look at the technology market as well – which is the subject of Chapter 5.

Table 3.1: Seed Replacement Rates for Cotton

(Ratio of seed purchased to seed used)

	2002/03	2004/05
Andhra Pradesh	92%	99%
Gujarat	86%	---
Haryana	76%	75%
Karnataka	94%	83%
Maharashtra	96%	93%
Punjab	55%	55%
Rajasthan	76%	65%
Tamil Nadu	100%	100%

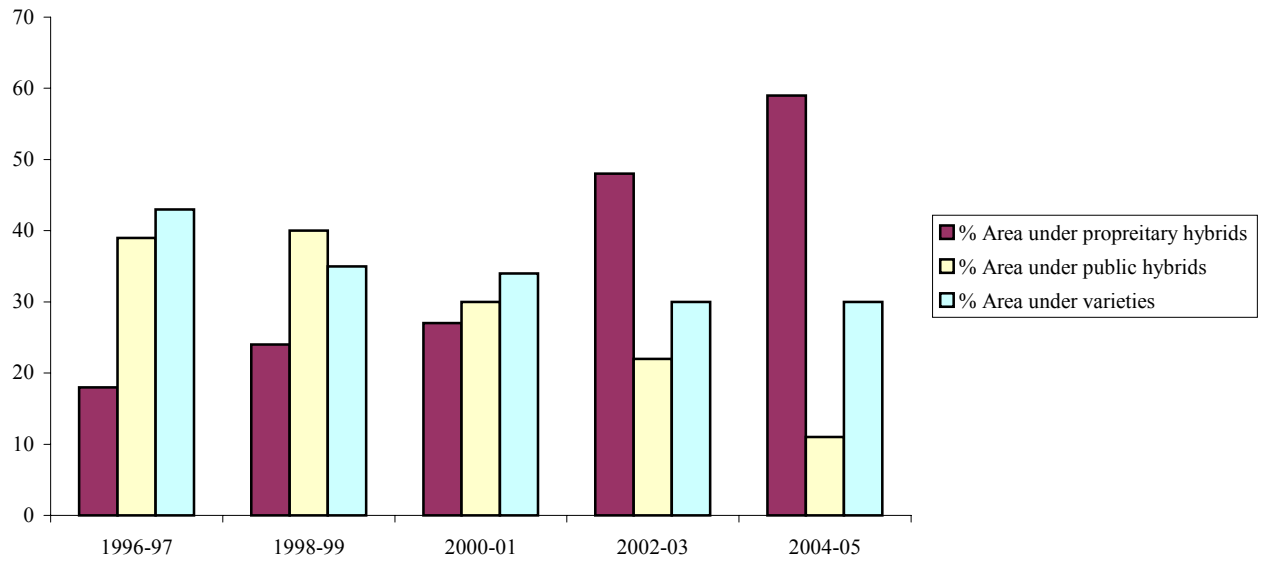
Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.2: Size of the Cotton Seed Market: Area, Volume, Value

Year	Area (m ha)	Volume (tonnes)	Value (Rs. Million)	Index of Value (deflated by wholesale price index)	Index of Value (deflated by wholesale cotton price index)
1996-97	9.07	60,011	5759	100.00	100.00
1998-99	9.31	46,438	6009	92.97	83.10
2000-01	8.28	34,943	5531	81.90	81.36
2002-03	7.24	30,581	6278	87.08	102.10
2004-05	8.6	32,882	11641	147.88	176.87

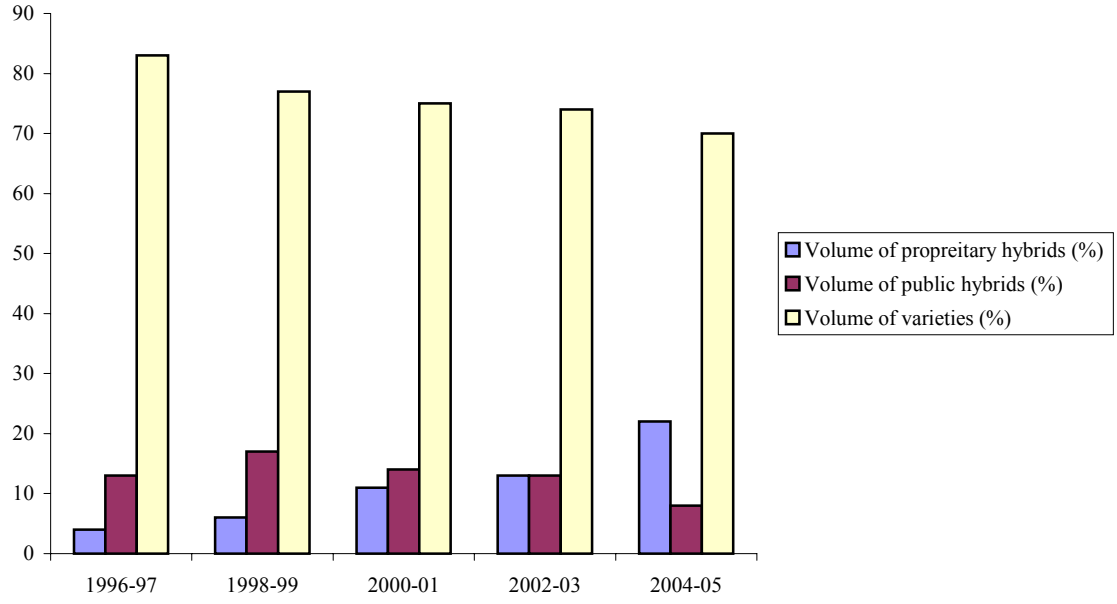
Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3.1: Composition of Area under Cotton



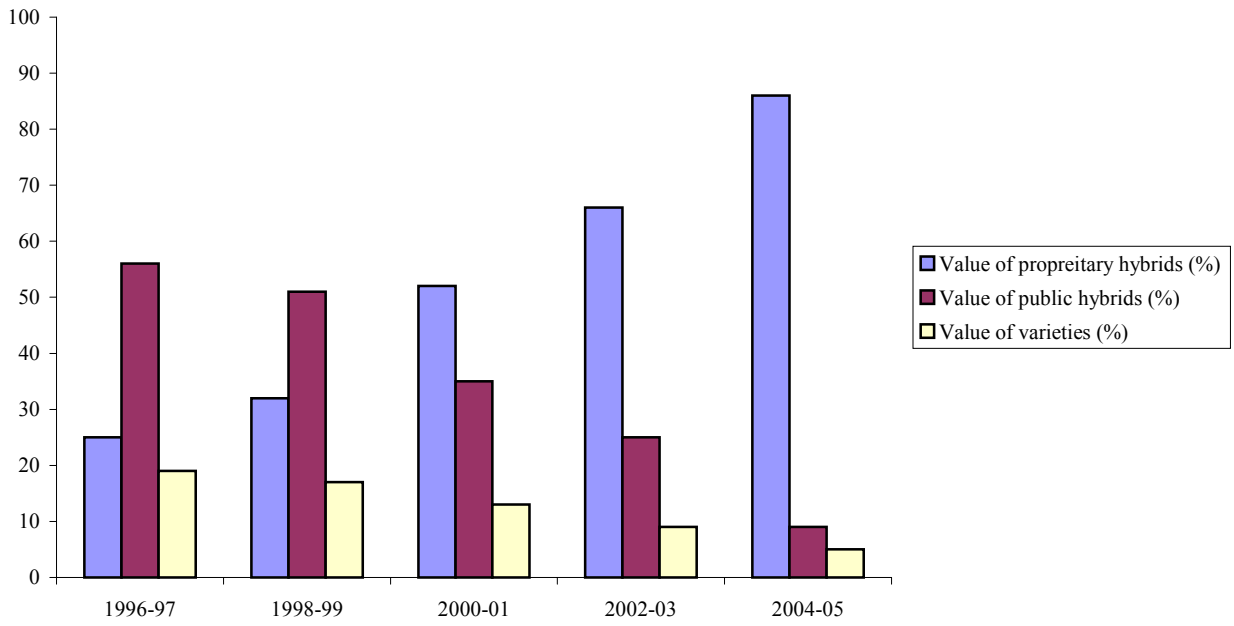
Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3.2: Composition of Seed Market by Volume



Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3.3: Composition of Seed Market by Value



Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.3: Seeding rates (kgs per ha)

Year	Proprietary Hybrids	Public Hybrids	Varieties
1996/97	1.33	2.19	12.84
1998/99	1.21	2.15	10.96
2000/01	1.68	2.01	9.31
2002/03	1.14	2.48	10.44
2004/05	1.42	2.66	9

Source: Computed from Francis Kanoi Marketing Research (2005). Seeding rates are calculated as the ratio of volume of seed sales to area

Table 3.4: % Share of Hybrids and Varieties in cotton area in Punjab

Punjab	Area (million ha)	Proprietary hybrids	Public hybrids	Varieties
1996-97	0.74	1	1	99
1998-99	0.56	1	---	99
2000-01	0.47	6	1	93
2002-03	0.46	11	8	81
2004-05	0.51	51	3	46

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.5: % Share of Hybrids and Varieties in cotton area in Haryana

Haryana	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	0.65	0	0	100
1998-99	0.58	0	0	100
2000-01	0.56	2	0	98
2002-03	0.55	5	2	93
2004-05	0.62	7	5	88

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.6: % Share of Hybrids and Varieties in cotton area in Rajasthan

Rajasthan	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	0.65	0	0	100
1998-99	0.63	0	0	99
2000-01	0.51	1	0	99
2002-03	0.40	0	1	99
2004-05	0.31	1	0	99

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.7: % Share of Hybrids and Varieties in cotton area in Maharashtra

Source: Computed from Francis Kanoi Marketing Research (2005)

Maharashtra	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	3.07	23	50	27
1998-99	3.20	32	52	17
2000-01	2.79	44	44	12
2002-03	2.61	65	26	9
2004-05	3.05	80	10	10

Table 3.8: % Share of Hybrids and Varieties in cotton area in Gujarat

Gujarat	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	1.48	23	59	18
1998-99	1.66	26	62	13
2000-01	1.62	43	48	10
2002-03	1.52	33	49	19
2004-05	1.93	47	9	44

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.9: % Share of Hybrids and Varieties in cotton area in Madhya Pradesh

MP	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	0.53	17	76	7
1998-99	0.50	12	82	6
2000-01	0.56	51	44	6
2002-03	0.55	63	28	9
2004-05	0.59	61	39	0

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.10: % Share of Hybrids and Varieties in cotton area in Andhra Pradesh

AP	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	1.02	42	36	22
1998-99	1.28	48	41	12
2000-01	1.02	73	18	9
2002-03	0.69	93	5	2
2004-05	1.17	81	11	8

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.11: % Share of Hybrids and Varieties in cotton area in Karnataka

Karnataka	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	0.67	2	76	22
1998-99	0.64	7	55	38
2000-01	0.56	7	24	17
2002-03	0.37	14	21	65
2004-05	0.23	32	7	58

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.12: % Share of Hybrids and Varieties in cotton area in Tamil Nadu

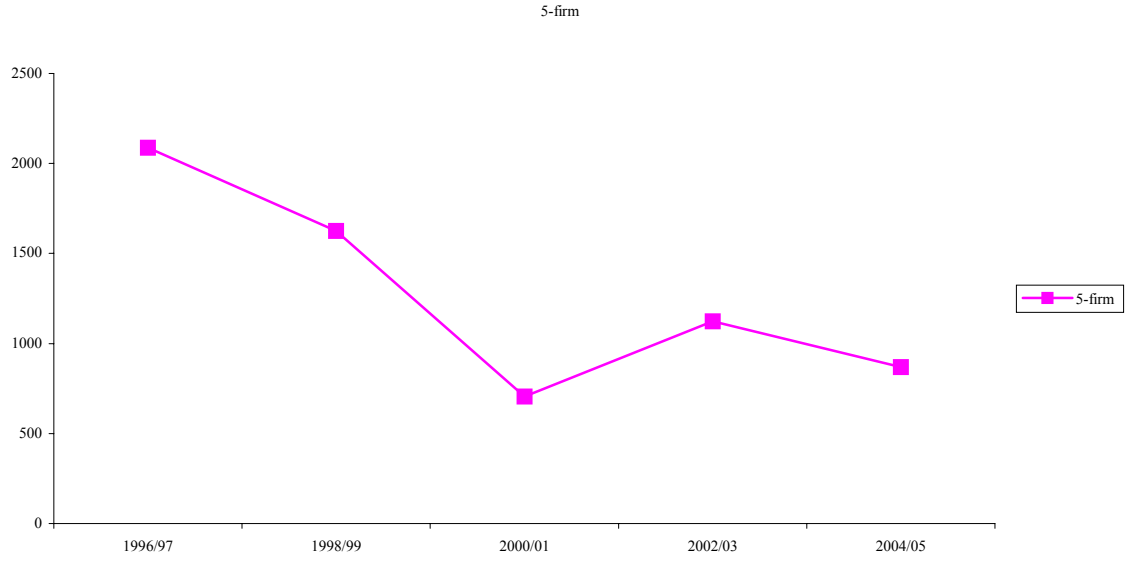
TN	Area (million ha)	Proprietary hybrids: Area	Public hybrids: Area	Varieties
1996-97	0.26	13	8	79
1998-99	0.25	34	2	65
2000-01	0.19	43	7	50
2002-03	0.09	38	4	58
2004-05	0.16	20	4	76

Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3.4: Share of top 5 firms in cotton proprietary hybrid seed market

Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3.5: 5-firm Herfindahl Index for the cotton proprietary hybrid seed market



Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.13: Growth in seed sales among top 10 firms

	Sales of top 5 firms	Sales of bottom 5 firms
1996/97	9.22	1.00
1998/99	10.35	1.45
2000/01	10.42	3.83
2002/03	13.29	3.26
2004/05	35.02	7.84

Source: Computed from Francis Kanoi Marketing Research (2005). All sales are normalized with respect to the seed sales by the bottom 5 firms in 1996/97

Table 3.14: Price of Seed, Rs per kg

	Public Hybrids	Proprietary hybrids excluding Bt	Official Bt	Unofficial Bt	All Proprietary hybrids	Price Gap between proprietary hybrids and public hybrids
1996/97	419	652	----	----	652	233
1998/99	383	711	----	----	711	328
2000/01	389	761	----	----	761	372
2002/03	397	1017	----	----	1046	620
2004/05	398	963	3517	2374	1391	565

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.15: Cost of Seed per ha, Rs

	Public Hybrids	Proprietary hybrids excluding Bt	Cost Gap between proprietary hybrids and public hybrids
1996/97	922	913	-9
1998/99	843	995	152
2000/01	856	1065	209
2002/03	873	1424	551
2004/05	875	1348	473

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.16. Evolution of Market Leaders in 1996/97

	Rankings according to seed sales				
	1996/97	1998/99	2000/01	2002/03	2004/05
Rasi	1	1	2	5	4
Mahyco	2	3	7	3	1
Ankur	3	2	1	2	5
Nath	4	6	----	----	----
Ajeet	5	4	6	8	----
Vikram	6	5	5	----	----
Nuziveedu	7	---	3	1	3
Syngenta	8	----	-----	6	----
Ψ^1	36	33	30	29	23
Ψ^2	36	32	26	26	-1

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.17 Evolution of Market Leaders in 2004/05

	Rankings according to seed sales				
	2004/05	2002/03	2000/01	1998/99	1996/97
Mahyco	1	3	7	3	2
Navbharat	2	---	----	---	---
Nuziveedu	3	1	3	---	7
Rasi	4	5	2	1	1
Ankur	5	2	1	2	3
Brahma/Paras	6	4	4	8	---
Tulasi	7	7	---	---	---
JK Seeds	8	---	---	---	---
Ψ^1	36	32	28	22	23
Ψ^2	36	28	20	15	19

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.18: Regional distribution of the hybrid seed market

States	2004/05	2002/03	2000/01	1998/99	1996/97
Punjab	0.05	0.02	0.01	0.00	0.00
Haryana	0.01	0.01	0.00	0.00	0.00
Rajasthan	0.00	0.00	0.00	0.00	0.00
Maharashtra	0.43	0.49	0.48	0.44	0.43
Gujarat	0.19	0.22	0.18	0.19	0.16
MP	0.10	0.10	0.10	0.10	0.11
AP	0.19	0.13	0.16	0.19	0.15
Karnataka	0.01	0.03	0.05	0.07	0.13
TN	0.01	0.01	0.02	0.02	0.02

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 3.19: 5-firm Herfindahl Index for Regional Markets (for Proprietary Seed)

	2004/05	2002/03	2000/01	1998/99	1996/97
Maharashtra	1116	1430	1529	2434	2074
Gujarat	3950	1480	3431	3509	2752
Madhya Pradesh	2491	757	926	1450	1984
Andhra Pradesh	1310	2097	1781	2534	3515

Source: Computed from Francis Kanoi Marketing Research (2005)

Chapter 4: Market Power in the Retail Market

4.1 Introduction

As discussed earlier, the proprietary cotton seed market consists of a branded and an unbranded segment. Overall, the unbranded segment could constitute upto 15% of the proprietary market. How does the unbranded segment coexist with the branded market? And how will the development of Bt technology affect unbranded seeds?

To answer these questions, we conducted a survey of seed dealers in Maharashtra. The questionnaire consisted of two parts. In the first part, we recorded the price of every cotton seed product (i.e., public variety, public bred hybrids, and proprietary hybrids) that the dealer sold in 2004 and 2005 crop season. In the second part, the dealer was asked to pick the top 3 hybrids by volume of sales at his outlet for both these years. The survey was done for the three major cotton growing regions: Khandesh, Marathwada and Vidharbha. Within Khandesh, all three districts (Dhule, Nandurbar and Jalgaon) were covered. In Vidharbha, 5 out of the 6 districts were randomly picked (Yeotmal, Amravati, Akola, Washim and Wardha). In Marathwada too, 5 districts (out of 7) were chosen but the survey could only be carried out in 4 districts (Nanded, Latur, Parbhani and Beed). The sample size for each district was fixed according to the size of the district and an initial enumeration of the seed shops in the district headquarters. The sample was chosen randomly with the restriction that at any location, not more than 4 shops would be sampled. After accounting for the nonresponse cases, the total sample size consists of 204 seed dealers across these 3 regions.

4.2 Product Proliferation

In the 2004 and 2005 kharif season, our survey records at least one sale of 199 cotton seed products across the 204 locations in Maharashtra. We use the term products as a generic term to include varieties, public bred hybrids and proprietary hybrids. Note that the same public bred hybrid when sold by two different companies counts as two different products. With respect to proprietary hybrids, we differentiate between the hybrids of the same firm. Thus, Ankur 651 and Ankur 2534, both hybrids from Ankur Seeds count as two different products. Bt hybrids were excluded from this study.

In 2004, 24 products did not register any sale while in 2005, the corresponding figure was 13. Even so the number of products within the cotton seed market is large. Industry observers segment the market in many ways according to product characteristics. Some of the important characteristics relate to performance with respect to moisture conditions (rainfed/irrigated), soil types, crop duration (early, medium, long), resistance to pests, fibre length, fibre strength and boll size. One industry participant had a breeding strategy based on 16 market segments.

Another reason for product proliferation is the presence of large number of products that are sold in only very limited number of locations, i.e., products that do not have a wide geographic presence within even Maharashtra. This factor is not unrelated to market segmentation which limits the use of some products to some regions. However, products with local presence only also arise from the unbranded seeds segment.

To see this, let s_{ict} be the sales of product *i* from shop *c* in year *t*. Define the indicator variable $g_{ict} = 1$ if $s_{ict} > 0$ and $g_{ict} = 0$ if otherwise. Then a measure of

geographical presence is $p_{it} = (\sum_{i=1}^{204} g_{ict} / 204)100$ where 204 are the number of seed dealers in our sample. Thus, p_{it} is the percentage of shops at which at least one unit of product *i* was sold in year *t*.

The distribution of this measure over the 199 products is displayed in Table 4.1 for 2004 and 2005 kharif season. In both years, 50% of products registered a sale at only 1% of shops (i.e., 2 shops). 75% of products registered a sale at only 4 to 4.5 % of shops (8 to 9 shops in the sample). Clearly then, an overwhelming number of products have an extremely limited presence in terms of geographical spread.

Of the 199 products, 154 are proprietary hybrids, 31 are public bred hybrids and 14 are public varieties. Among the public bred hybrids, there are several versions of the same hybrid that are counted in our survey as different products because they are sold under the brand names of different firms. Thus, for instance, NHH44 is sold by as many as 20 different firms. Hence the overall product proliferation is largely due to the large number of proprietary hybrids. It follows that it is most of these proprietary hybrids that have an extremely limited geographic presence.

4.3 Unbranded Seeds and Dealer Power

The large number of proprietary hybrids with an extremely localised presence is consistent with the existence of an unbranded seeds segment that is characterized by little or no product promotion. Firms typically build up brand power with demonstration visits and field days at different locations. Growers are invited to spend time at demonstration plots where the proprietary hybrids are exhibited along with a check variety. Growers also interact with company officials and receive some extension advice. Industry

observers indicate that a firm could spend between 5 to 10% of the value of sales in such activities the costs of which include preparation of demonstration plots, transport and food expenses of growers. The other advantage of purchasing branded seeds is ex-post quality assurance – firms are sensitive to quality complaints because of possible damage to their reputation and also because such complaints could invite action by the government (which includes suspension of license to sell seeds in the state). Seeds are good examples of "experience" goods (in contrast to "search" goods) where the buyer learns about the quality of product only after purchase of the seed. Economic theory predicts that with such experience goods, firms will invest in advertising, warranties and other means to communicate product quality to buyers (Tirole, 1988). The marketing literature contains ample empirical evidence to support this proposition.

Why do then growers purchase unbranded seeds which have no reputation and which do not offer the ex-post quality assurance of branded seeds? While a conclusive answer to this question is beyond the scope of this study, we conjecture that it is because of dealer power. In most cases, seed purchases by growers are financed by credit extended to them by seed dealers. Because of credit ties, growers are locked into a relationship with a particular dealer. This gives dealers the power to influence seed choices. Going by the trade practice as reported to us, dealers rarely dictate that a grower should buy unbranded seeds to meet their entire requirement. The more common practice is to modify, at the margin, a farmer's preference for a particular branded seed. The grower is encouraged to try out an unbranded seed for some portion of his requirements. The incentive for the dealer come from the reported `fact' that the margins on unbranded seeds are greater than on branded seeds by a multiple of three to four. We now turn to

some results from our survey that could throw light on our conjecture of dealer power in influencing sales of unbranded seeds.

In the survey, prices are reported per packet of seed. The weight of a packet of seed varies between proprietary hybrids, public hybrids and varieties and sometimes within the category itself (especially in the case of variety). From the price and weight data, we derive the unit price of a gram of seed. To see its relation to the market power of the firm, we use the seed dealer's response in ranking the top 3 products sold through his outlet. For each seed dealer, we create a market power dummy, which assigns the three top ranked products the value 1, and the value zero to the other products sold by the dealer.

Table 4.2 reports 3 regressions. In the first regression, the log of unit price in 2004 is regressed on the product type dummy (whether public hybrid, whether variety), the market power dummy for 2004 (called leader04) and the product terms of these two types of dummies. As expected, unit prices for proprietary hybrids are the highest – more than twice of public bred hybrids and many times that of public varieties. Further, the regression shows that on average, the price premium for market leaders is of the order of 4%. In the second regression, the dependent variable is the log of unit price in 2005 and the market power dummy is that for 2005 (called leader05). In the third regression, the dependent variable continues to be the log of unit price in 2005 but the market power variable is now leader04. As can be seen, the second and third regressions are very similar to the first one and the price premium for market leaders varies between 4 to 5% only.

These results suggest that the gain in terms of price premium from market leadership and presumably brand investment are extremely modest. Why do then firms bother with brand investment? The answer lies in dealer margins. According to our interviews with seed companies and dealers, the companies with brand acceptance offer dealers margins not higher than 15% of the seed price. On the other hand, companies with little or no brand acceptance would need to offer substantially higher dealer margins (our interviews cite numbers ranging between 35 to nearly 50%).

In summary then, we see very modest price premiums on account of market power in the cotton seed market. The grower pays about the same price whether the seed is branded or not branded. However, the market leaders receive a higher share of the selling price because they can get away with lower dealer margins. However, companies with no brand presence cannot push sales without offering dealers higher margins. Dealers derive their power from their ability to influence seed purchases of their clientele. If they did not have this power (if, for instance, growers had other credit sources) then companies with no market power would have to compete by selling at substantially lower prices – in effect transferring the major part of dealer margins to the consumer.

4.4 Using Alternate Measures of Market Leadership

The market leadership variables of the previous section is subject to biases on account of imperfect recall by the dealer as well as dealer's perceived interests in overstating the sales of products in which he receives higher commissions. Notice that the leader04 (and the leader05) variable is defined for each dealer. If the set of the top 3 products vary from dealer to dealer in a completely random way, the union of all these

sets would be the same as its complement. However, that this is not so, is clear from the regressions in Table 4.2 that clearly imply that the market leader variable has predictive power. Hence, when we consider the top 3 sets of each dealer, it must be that some products get repeated quite often in the set of top 3 products. This suggests an alternative definition of market leadership based on the measure of geographical presence defined in 4.2. In a probit regression of the leader04 dummy on the log of the measure of geographical presence, the elasticity at the mean (of the explanatory variable) is as high as 0.6. Similar results obtain for the leader05 dummy as well. Thus, the market leadership variable is highly correlated with geographical presence.

Suppose we define a dummy that takes the value 1 for products that are in the top 5 percentile of all products by the measure of geographical presence. We call this Top5. Similarly, we can define the Next5 dummy for all the products that are in percentiles 90 to 95. Table 4.3 reports the unit prices regressions with these market power variables. We report the regressions for only proprietary hybrids (hence the product type variable is omitted) and to remove the presence of those hybrids that are very infrequently sold, we consider only hybrids that were sold in at least 8 locations. The results indicate a 9 to 10% price premium for products in the top 5% percentile measured by geographical presence but a statistically insignificant price premium for the products in the next 5% percentile.

4.5 Conclusions

From a survey of seed dealers across 3 regions in Maharashtra, we found that a large variety of cotton seed products (whether public hybrids, proprietary hybrids or

public varieties) were sold in the years 2004/05 and 2005/06. The proliferation in products was due to proliferation in proprietary hybrids. However, only a small subset of these products was sold across most of the locations. The larger subset of products consisted of proprietary hybrids that had an extremely local presence and can be thought of as belonging to the unbranded seeds segment.

Despite seed being an `experience' good, the presence of unbranded seeds owes itself to dealer power that in turn derives from their credit relationships with growers. Firms that invest in brand presence obtain their returns through low dealer margins rather than price premiums, which are quite small. Even in the most refined case, the price premiums are of the order of 10% and that too is earned only by a very restricted set of market leaders. This is presumably because dealers are able to use their leverage in order to be able to push unbranded seeds at prices nearly equivalent to branded seeds.

Table 4.1: Distribution of the measure of geographical presence

Percentiles	$p_{i,2004}$	$p_{i,2005}$
1%	0.00	0.00
5%	0.00	0.00
10%	0.00	0.49
25%	0.49	0.49
50%	0.98	0.98
75%	3.92	4.41
90%	30.39	24.02
95%	50.49	52.45
99%	86.27	87.25
# products	199	199
Mean	7.57	7.83
standard deviation	16.93	17.22

Table 4.2: Regression of unit price on market power variables

	Dependent Variable: Log of unit price in 2004		Dependent Variable: Log of unit price in 2005		Dependent Variable: Log of unit price in 2005	
Explanatory Variables	Coefficient Value	t-values	Coefficient Value	t-values	Coefficient Value	t-values
Whether public hybrid	-0.78	-47.8	-0.76	-51.66	-0.76	-51.82
Whether variety	-2.88	-102.83	-2.92	-98.30	-2.92	-98.32
Leader04	0.04	3.11			0.05	3.81
Leader05			0.04	3.68		
Whether public hybrid X leader04	0.37	5.25			0.33	4.08
Whether variety X leader04	2.37	79.61			2.40	76.69
Whether public hybrid X leader05			0.27	3.64		
Whether variety X leader05			2.41	76.96		
Constant	-0.16	-27.54	-0.16	-25.89	-0.16	-26.09
# Observations	3017		3134		3134	
R^2	0.90		0.89		0.89	

*t-stats are based on standard errors robust to heteroscedasticity.

Table 4.3: Regression of unit price on market power variables based on geographical presence

	Dependent Variable: Log of unit price in 2004		Dependent Variable: Log of unit price in 2005		Dependent Variable: Log of unit price in 2005	
Explanatory Variables	Coefficient Value	t-values	Coefficient Value	t-values	Coefficient Value	t-values
Top5 in 2004	0.09	4.07	0.10	4.51		
Next5 in 2004	0.03	1.35	0.02	1.03		
Top5 in 2005					0.08	4.73
Next5 in 2005					0.01	1.05
_cons	-0.21	-9.57	-0.21	-9.81	-0.19	-12.03
# Observations	2193		2278		2303	
R^2	0.24		0.25		0.24	

Note: This regression is done only for proprietary hybrids and within that category for those proprietary hybrids that were sold in at least 8 of the 204 locations. t-stats are based on standard errors robust to heteroscedasticity.

Chapter 5: Technology and Regulation

5.1 Entry Barriers: Pre-Bt

In understanding how seed markets may evolve in the future, it is useful to look at entry barriers and cost advantages that could favour large incumbents. Our analysis in this chapter is largely based on interviews with seed companies.

It is commonly agreed that conventional plant breeding does not require much capital investment. Breeders, a collection of germplasm, and land for an experiment station are the principal inputs. As mentioned earlier, the private sector has often hired breeders from public sector research institutions and agricultural universities. Germplasm was not mentioned as a constraint by any of the seed companies that we interviewed. The size of experiment stations varies between 25 hectares for a modest breeding program to over 100 hectares for an experiment station spread over multiple sites. Marker assisted breeding is beginning to be important but as the cost of this technology is not prohibitive, it is unlikely to be a dominant source of technological advantage for larger firms.

Among the nontechnological factors, the biggest issues in scaling up are the needs for working capital and the ability to bear risk. Seed production is organized through contract growers and this needs to begin one year before sales commence. Growers receive an advance (about a sixth of the price of seed) and they are fully paid by April-May. Risk is an issue because seed production is based on one-year ahead forecasts of demand (for the firm's proprietary hybrid). Cautious firms could therefore miss opportunities to become market leaders.

From the account in chapters 2 and 3, it is clear, however, that these barriers have been only modest hurdles. The proprietary seed market has seen entry by a number of firms in the last decade.

5.2 Entry Barriers: Post-Bt

In India, the first approvals to Bt cotton were given to three hybrids released by Mahyco Monsanto Biotech (MMB), the joint venture between Mahyco and Monsanto. These hybrids contained the Bt gene *cry1Ac* owned by the U.S. firm Monsanto. Subsequently, MMB has sub-licensed the gene to 20 other firms in India (as of April, 2005) to incorporate it into their cotton hybrids.

To the sub-licensee of the cry 1 Ac gene, MMB provides the gene incorporated in an American variety called Coker 312. Through routine backcrossing with the parental lines of its hybrids, the sub-licensee firm incorporates the gene into its germplasm. Hybrid seed is then produced in the usual manner. The principal investments (besides the license fee) by the sub-licensee consist of equipment that isolates DNA (through grinding and centrifugal force), tests for the presence of the Bt protein (Elisa test), tests for tracking plant transformation (homozygosity tests using PCR) and greenhouse for contained field trials. According to several respondents, such equipment together with related essentials (such as refrigeration) and infrastructure (temperature controlled buildings with back up power) cost about Rs. 5 million. Many seed firms go beyond these essentials and also invest in plant pathology labs, machines for DNA sequencing and characterization and multiple Elisa machines to be used for testing Bt presence in seeds produced by their growers. For this reason, many seed companies reported

budgeting around Rs. 10 million for the biotech lab. MMB charges a licensing fee of Rs. 5 million.

While Rs. 15 million is a quantum jump in R&D expenses for most seed firms, the economics of such investment can be considered for a small firm selling 100,000 packets annually. For a packet of seed (450 grams), MMB has fixed a trait value of Rs. 1200 of which Rs. 700 is paid to MMB (this is in addition to the lump sum licensing fee of Rs. 5 million) and Rs. 200 to the seed dealer. If the firm expects to sell the seed at Rs. 1600 (the lowest price for seed among the official Bt providers), its share of the selling price would be Rs. 700 and its expected revenues would be Rs. 70 million. As non-Bt hybrids sell for around Rs. 400 per packet, the incremental revenues due to Bt is of the order of Rs. 30 million annually. Thus, even for a small firm, the additional R&D cost due to Bt related investments could be recouped quite rapidly provided the assumptions about expected sales and price hold.

The Bt related investments are therefore unlikely to be a barrier to entry into the Bt market by the firms in the branded segment. This is also borne out by the large number of seed firms that have licensed the Bt gene from MMB.

5.3 Competition in the Post-Bt Scenario

Despite the conclusion in the previous section that Bt related investments do not constitute an entry barrier, the impact of Bt on market structure is likely to be complex. According to industry estimates, there has been a marked shift in farmer preferences towards Bt seed. Of the total hybrid seed market of 13 million packets, industry sources estimate that Bt seeds could account for as much as 8-9 million packets in 2005 (up from

3 million packets in 2004 season). Illegal Bt seed is thought to account for 5-6 million packets while the remainder is legal Bt seed.

In this section, we analyze the factors that would shape competition in the post-Bt world. For convenience, the discussion is sorted into three themes.

(a) *Competition between Seeds with Monsanto's cry 1 Ac gene*

Although about 20 firms have licensed the cry 1 Ac gene from MMB, not all of the 20 firms will have their Bt products in the market at the same time. For instance, in the 2005 season, besides MMB, hybrids from Ankur, Rasi and Nuziveedu were available to growers. Hybrids from other firms are still in large-scale trials awaiting the biosafety regulator's approval (the Genetic Engineering Approval Committee or GEAC) or at even more preliminary stages of testing. Some of the licensees have concluded their agreement with MMB in 2005; thus they are just beginning to do backcrossing. On the other hand, Rasi's agreement with MMB dates from 1998 . They did large-scale trials in 2002 and 2003 and obtained GEAC's permission to commercialize in 2004. Hence, the fact that not all firms have started their Bt programs at the same time means that firms that got a headstart might receive the opportunities to enjoy monopoly power temporarily. GEAC's insistence on agronomic testing (through large scale trials) favours the firms that have already received commercialization approvals.

The case for agronomic testing relies on the need to protect poor and vulnerable growers from inferior products. Yet, growers have not shown a marked preference for hybrids that have undergone agronomic testing. Under India's seed laws, agronomic testing (by which varieties and hybrids are "notified") is mandatory for public varieties and public hybrids but is voluntary for proprietary non-Bt hybrids. Most firms have not

bothered with the notification process and have relied on their own quality systems, demonstration plots and field days to build brands and push sales. In some cases, for the sake of public relations with the government and the public sector agricultural research establishment, firms submit their flagship hybrid to the notification trials but almost never wait for the outcome to market their product.[15] In the perception of seed firms, notification adds little or no commercial value. The dominance of non-notified proprietary hybrids in the cotton seed market demonstrates this amply.

The hybrids from MMB, the first firm to apply for commercialization, spent 4 years in large-scale trials including two years of testing with ICAR trials. By allowing concurrent ICAR and large-scale trials (organized by the applicant), GEAC quickened the process to 2 years for Rasi, which was then reduced to 1 year for the approvals in 2005 including that of Nuziveedu Seeds. However, since then, the GEAC revised its protocol to specify that non-notified Bt hybrids would have to spend upto 2 years in ICAR trials, thereby increasing the time before which new Bt hybrids can come to the market.

While the entry of more Bt hybrids would offer growers more choices and lessen concentration, the impacts on price would be muted. As we saw earlier, by the revenue sharing agreement with MMB, the trait value is fixed and a sub-licensee firm receives Rs. 700 and an increment of Rs. 300 over the price of nonBt seed (if the Bt seed sold at the current market price of Rs. 1600). Rs. 300 is therefore the additional surplus (gross of costs due to Bt) received by the seed company. Competition could therefore affect this quantity and it represents the maximum amount by which price could fall.

[15] A fairly typical example is that of Vikram 9 and Vikram 5 from Vikram Seeds. They were released in 1993 and 1995 and were very successful hybrids in Gujarat till 2003. Both hybrids were also tested in notification trials and were notified in 2000 and 2002 respectively.

(b) *Competition between different Bt genes*

As of now, MMB's cry 1 Ac gene is the only Bt gene that has been approved by the biosafety regulators in India. Large scale field trials have been permitted in the 2005 crop season for hybrids incorporating four other gene constructs – MMB's Bollgard II which stacks *cry* 1 Ac and *cry* 2 Ab genes, a modified *cry* 1 Ac gene developed by IIT, Kharagpur in collaboration with JK Seeds, a `fusion' *cry* 1Ac/cry 1Ab gene sourced by Nath seeds from the Chinese Academy of Agricultural Sciences and Vip genes (also isolated from Bt bacteria) from Syngenta. These genes have undergone biosafety tests and the hybrids incorporating them have to go through the agronomic testing discussed earlier.

The hybrids based on non-Monsanto genes are expected to be in the market in 2007 season if the regulators insist on 2 years of trials but could be commercialized in 2006 if one year of trial is deemed sufficient like in the case of some regulatory approvals in 2005. Like in the previous case of competition between hybrids with Monsanto's genes, GEAC's agronomic testing is an entry barrier that favours incumbent firms – the MMB gene in this case.

The competition from alternative genes could lead to a more serious impact on the seed price than the competition between hybrids with the MMB gene. This is because the alternative gene providers could target a trait value lower than that fixed by MMB. Whether this will happen and to what extent will depend on two factors: (a) The performance of these alternatives as compared to MMB's genes especially Bollgard II which promises protection not only against lepidopetran pests but also spodoptera – a rapidly emerging pest. (b) MMB's first mover advantage in sub-licensing the Monsanto

genes to firms that have some of the best performing hybrids in the country. Even if the alternative gene constructs prove successful, they would not be able to combine with quality germplasm. Thus, the market for the new genes may well be limited by the contractual restrictions of the major seed firms with MMB.[16]

(c) *Illegal Bt*

Illegal Bt originated in Gujarat and is still dominant there. But it has also spilled over to Maharashtra, Punjab and Andhra Pradesh. Industry sources acknowledge that in these states, while illegal Bt is not dominant, it is not uncommon either. Navbharat 151 is a generic name for illegal Bt. In interviews, industry observers stated that the male parent (with the Bt gene) used in Navbharat 151 has been crossed with a variety of female lines to generate many different versions of illegal Bt, often well adapted to local environments.

In the 2004 season, illegal Bt was priced anywhere between Rs. 800 to Rs. 1200 per packet. With its seemingly effective performance and its lower price, illegal Bt is a threat to legal seed, whether Bt or otherwise. The threat is particularly acute for non-Bt hybrids. With legal Bt, the non-Bt market has some protection in terms of a large difference in seed price. With illegal Bt, the protection is much less. In Gujarat, for instance, the market leader Vikram Seeds lost its non-Bt market rapidly because of illegal Bt.

The following facilitates illegal Bt's spread:

[16] Several firms indicated that the agreement with MMB disallowed the license of genes (with insect-resistant traits) from other companies. However, they cited confidentiality reasons in declining us access to this clause.

(a) It can be priced lower than legal Bt because the seed value does not have to be shared with the gene supplier. Even if competition between legal Bt hybrids improves their performance or lowers their price, illegal Bt could compete by further lowering its price.

(b) The illegal Bt coming out of Gujarat is regarded as being of good quality. Within Gujarat, illegal Bt is served by a large network of seed producers and distributors. Anecdotal accounts of grower experience speak of farmers receiving quality assurance from this network.

(c) Illegal Bt generates large gains for seed dealers and seed producers and therefore can be shared with local authorities that have the power to enforce seed laws.

As against these factors, the spread of illegal Bt can be limited by the following factors.

(i) Transactions have to be based on trust and carried out in cash. Seed dealers and producers cannot use normal banking facilities and nor can they use regular commercial channels for dealing with first time buyers (i.e., seed dealers from outside their area of operations). Illegal trade becomes difficult to carry out without kinship networks, which are geographically restricted.

(ii) Illegal Bt is marketed without a company name and a bill of purchase. In Gujarat, some illegal seeds are known by brand names such as Kavach and Rakshak. But it would be difficult to build these brands (without risking counterfeiting) over geographically dispersed areas. Illegal Bt producers do not possess the formal means to communicate quality especially to growers not within their traditional areas of operation. In areas outside Gujarat, growers are confronted with the issue of spurious Bt. One estimate is that 30% of all seeds marketed as illegal Bt in Maharashtra is spurious. Kurnool in

Andhra Pradesh is another center for illegal Bt production and proliferation. However, Kurnool Bt as it is known has developed a reputation for having more quality problems than Gujarat Bt. Thus, the internal governance systems developed by Gujarat seed producers may not carry over easily to other locales.

(iii) With better gene constructs such as Bollgard II, legal Bt will perform better than illegal Bt.

5.4 Concluding Remarks

Although proprietary seeds have enjoyed a robust growth over the last decade and new firms have entered the market, the current situation is characterized by significant uncertainty about future market dynamics. At the ground level, there is a substantial shift of farmer preference towards Bt seeds as a result of which firms find it imperative to come out with Bt hybrids. Almost all the major firms have tied up with MMB (the single source for this technology as yet) possibly enhancing the monopoly of MMB licensed genes for the future as well. Significant investments have been made and firms are impatient to get to the market as early as possible when competition in the Bt market is still weak. The uncertainties stem from the competition from illegal seeds, from other genes in the testing process and also from regulatory policies. Firms looking to enter are fearful of regulatory capture by incumbent firms.

Chapter 6. Conclusions

6.1 The Growth of the Private Sector

As the previous chapters have shown, the private cotton seed industry made rapid advances in the last decade and half. In the absence of tight IPR laws, the private sector has grown through investment in proprietary hybrids. Starting in the late 1980s, economic reforms in India removed policy barriers to entry by foreign and large domestic firms. However, this is not directly responsible for the growth in the private sector as such entry has been limited. Unlike the experience in developed countries, firms from allied sectors (agro-chemicals, biotech) have not acquired seed companies. Among the foreign majors, Monsanto and Syngenta have significant presence in the Indian cotton seed market. However, Monsanto's investments in Indian seed companies date from the mid-90s and therefore cannot explain the flurry of proprietary hybrids that were released prior to and around that time. Syngenta has had a longer presence but by itself its activity is too small to explain private sector activity. Thus, the growth in proprietary hybrids and in the private cotton seed sector has been primarily driven by domestic firms riding paradoxically on the success of the earlier generation of public bred hybrids.

The commercial potential of cotton hybrids was established by the public sector – the one exception being the hybrids from Mahyco. Once this model was established by the late 1980s, many private companies, which started out typically as distributors and producers of public varieties and public bred hybrids, began to develop and market proprietary hybrids in the 1990s.[17] The public sector offered a ready pool of technical expertise especially in the form of retired breeders. The role of the public sector in

[17] This is similar to the account in Fernandez-Cornejo (2004) about the growth of the private maize seed industry in United States.

diffusing knowledge – both technical and commercial – within the seed industry deserves further examination.

By the late 1990s, public bred hybrids were beginning to lose ground to proprietary hybrids and by 2004/05, public bred hybrids have been eclipsed. Unlike public bred hybrids, proprietary hybrids received marketing attention. Furthermore, the private sector focussed on relevant products that filled the gaps in public bred hybrids such as with regard to crop duration and fibre quality.

6.2 Consolidation in the Seed Market

The rapid growth of the proprietary seeds segment has not been accompanied by greater consolidation in the cotton seed industry. From the mid-1990s, the concentration in the proprietary cotton seed market has declined at the national level and in the two major markets of Maharashtra and Andhra Pradesh. In Gujarat and Madhya Pradesh, the advent of Bt hybrids has reversed the trend of weakening concentration. As the proprietary market has grown, more private players have come into the market eating away at the share of the market leaders.

At the same time, the set of market leaders has itself shown flux. Taking into account market leadership at the regional level, there are at least fifteen firms with successful cotton hybrids. Markets with local monopolies have to contend with this set of potential entrants. Judged by commonly used concentration indices, the entry of new brands, the fluctuation in market leaders and the number of established brands, the proprietary seed market has become more competitive over the last decade.

The capital requirements of conventional plant breeding are modest. Working capital requirements and risk bearing capacity are probably greater entry barriers. However, in the Indian context, they have not been formidable enough to preserve the advantages of the incumbents.

6.3 The Retail Market

In the textbook definition of competitive markets, products from rival suppliers are perfect substitutes. This is not true of seed markets that are better thought of as offering differentiated products. Models of monopolistic competition are therefore closer to real world seed markets than perfect competition models.

Product differentiation in the seed markets arises not just from the varietal characteristics themselves (such as pest resistance, maturing period, boll size) but also because seed firms would like to signal quality. As seeds are "experience" goods whose quality is possible to ascertain only after purchase, firms have incentives to invest in brand development and quality assurance systems.

Despite this, the proprietary seed market contains an unbranded segment that could account for upto 15% of sales. Furthermore, our data analysis reveals that branded seeds receive only a modest price premium over the unbranded seeds. Our explanation is that it is because of the power of seed dealers. Due to credit linkages (for seeds as well as other inputs), seed dealers can influence the choices of growers and be able to sell unbranded seeds to them at a price nearly equal to that of branded seeds.

At the retail level, therefore, both the branded seeds and the seed dealer enjoy some market power. To the extent that branding signals quality, farmers gain by having higher

quality seeds. As for the seed dealers, their market power derives from imperfect credit markets despite decades of investment in rural credit infrastructure.

6.4 IPRs, Technology and Regulation

With Bt cotton, the seed industry encompasses a seed market as well as a technology market. As of now, the technology market consists of only one supplier – Monsanto Mahyco Biotech (MMB) that has licensed its Bt gene to almost all the leading cotton seed companies. For a seed company, developing a Bt product means a substantial hike in R&D expenses. However, at current prices (for Bt seeds), the investment is rapidly recouped even for medium-sized firms. As a result, as many as 20 firms (as of April 2005) had licensed the Bt technology from MMB. These firms are, however, contractually bound to pay royalties to MMB, which sets a floor to Bt seed prices even with competition among these firms.

Bt seed prices are about four times that of non-Bt hybrids. Even at this price, several studies have estimated that farmers on average have gained substantially from Bt cotton (Bambawale, et. al, 2004; Bennet et. al, 2004; Naik et. al, 2005; Qaim, 2003). However, the relatively high price of Bt seeds has drawn adverse attention from NGOs (for instance, Sahai and Rehman, 2004).

MMB's position as the sole gene supplier is not protected by intellectual property laws. Although India now provides for plant breeders' rights, it has not been operationalised. Even if it were, the private seed industry is unlikely to use it because the rights as they exist are so weak as to provide few incentives for innovation (Srinivasan, 2004). As for patent laws, India's compliance with TRIPs norms could mean that technology suppliers could patent genes. However, the patents office has not yet granted

any claim. In our interviews with seed company officials, patenting was not regarded as an important element of the current business environment.

MMB has derived a measure of protection for its gene through bio-safety laws. As biosafety approvals are obtained for the composite of the gene and the germplasm, hybrids that incorporate MMB's gene but do not go through the biosafety process are illegal. While this has not stopped the diffusion of illegal Bt seeds, it has led the seed companies that wish to work within the law (consisting of all the established firms with branded products) to either deal with MMB or consider an alternative Bt strategy. At this point, most of the firms have chosen to license the Bt technology from MMB.

To what extent MMB can use its first mover advantage and whether this advantage will be breached depends on future diffusion of illegal seeds, competition from alternative gene suppliers and regulatory practices. The uncertainties about each of these factors translate into future market dynamics and this could be a barrier to future entry and innovation. Besides a stable regulatory environment, public policy must address the failure of public sector research institutions in staking out a presence in the technology market.

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