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Competition and Monopoly in the Indian Cotton Seed Market*

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Abstract

The private sector has become an important supplier of varietal technology in agriculture. This has given rise to concerns about competition in the seed market. This study examines the evolution in the structure of India's cotton seed market and the factors that underlie the changes. The study finds that the private sector has grown rapidly in the last decade. More than a decade after the removal of FDI restrictions, the presence of foreign majors remains limited. Domestic firms have driven the rapid growth and this has not been accompanied by greater consolidation in the industry. As the proprietary hybrid seed market has grown, more private players have come into the market eating away at the share of the market leaders. 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.

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Competition and Monopoly in the Indian Cotton Seed Market

1. Introduction

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. Once farmers obtain new crop varieties, they can save, multiply, exchange and sell the seed for many years. Consequently, the development and distribution of new crop varieties is typically an activity of the public sector.

In recent years, however, 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). The rise of the private seed sector is associated with the development of hybrid varieties. As is well known, seed from hybrid-seeded crops cannot be used without major yield reductions in future generations. As a result, hybrid seed tend to be repeatedly purchased which provides a mechanism for private technology suppliers to appropriate a significant enough share of the gains from higher yields.

The rise of the private sector means that the gains to farmers from new seeds depend on the structure of seed markets. 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. With more than Rs. 1000 crores in sales, the Indian cotton seed sector is one of the largest cotton seed markets in the world. While products of public sector breeding traditionally dominated this sector, the bulk of value is now accounted by private seed firms. 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. Therefore, it is reasonable to suppose that this is the sector where changes in market structure are likely to have been the most important.

The literature on seed market structure in developing countries is meagre. 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.

2. The Private Sector in Cotton Breeding

India was the first country in the world to commercialize cotton hybrids. The first cotton hybrid H-4, was intra-*hirsutum* and was produced by Dr. C. T. Patel in 1970 at the Surat agricultural experiment station of the Gujarat Agricultural University. The public sector's research program has been broad 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. The public sector released many location-specific hybrids in the late 1970s and early 1980s. 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.

The first private sector cotton hybrid was MECH 11 commercialized by Mahyco in 1979. However, it was only in the 1990s that other seed companies released their cotton hybrids. The successful private sector hybrids are usually intra-*hirsutum* hybrids serving the major markets of Maharashtra, Gujarat and Andhra Pradesh. 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 have played a role in the rapid development of the private sector hybrids in the 1990s. First, their growth is the outcome of 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.[1] Furthermore, the private sector has relied heavily on retired public sector breeders to lead their research effort. The knowledge spillovers from the public sector R&D activity have therefore been substantial. 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 developed 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 private 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

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

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.

3. Bt Cotton

Bacillus thuringiensis is a soil borne bacterium toxic to insect pests and safe to higher animals. It is 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). The commercial release of plant varieties produced through genetic engineering requires approval from biosafety regulators.

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 which licensed the gene to MMB in India. Subsequently, MMB has sub-licensed the gene to 20 other firms in India (as of April, 2005) to incorporate it into their cotton hybrids. As of 2006, 44 cotton hybrids (from 14 seed companies) using this gene construct had been approved for different cotton zones in India.

In 2006, the regulator – Genetic Engineering Approval Committee (GEAC) - also approved three 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, and a `fusion' *cry* 1Ac/cry 1Ab gene sourced by Nath seeds from the Chinese Academy of Agricultural Sciences. 14 cotton hybrids (from 5 different seed companies) incorporating these gene constructs were approved in 2006 for commercial release.

The first approval to the MMB varieties was preceded by the discovery of an unauthorized Bt cotton hybrid in farmers' fields at the end of 2001 in Gujarat. The illegal variety was NB 151, a variety registered with the Gujarat government as a conventional hybrid. It belonged to Navbharat Seeds, a firm based in Ahmedabad. Later investigation confirmed that the Bt gene in NB 151 is the Cry 1 Ac gene developed by Monsanto and used in the legally approved varieties. As a result, Navbharat Seeds is barred from the cotton seed business and is being prosecuted for violating biosafety laws. Yet despite this, illegal seed continues to be planted especially in Gujarat. 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. NB 151 is now a generic name for illegal seed.

4. The size and composition of the cotton seed market

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 latest year for which we have information is 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.

Table 1 shows the size of the cotton seed market by area, volume and value. 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.[2]

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. 1150 crores which is about a fourth of the total market for 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 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

[2] 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.

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 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). 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]

Figure 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 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. We have shown elsewhere that about half of the increase in value of proprietary hybrids is because of the diffusion of Bt cotton (Murugkar et.al, 2006).

The segment that the private sector occupies is the dominant one. In 2004/5, hybrid seeds (public + private) occupied 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 were dominated by varieties.

[3] For detailed tables on each of the states, the reader is referred to Murugkar, Ramaswami and Shelar (2006).

5. 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.[4] 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 as 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 15,000 and 30,000 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%.[5]

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

[4] Public hybrids are sold in packets of 750 grams.
[5] 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.

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.

Figure 4 displays the market shares (by volume) of the top 5 firms (the 5-firm concentration ratio) in the proprietary hybrid seed market. Figure 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. 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 (table 2) shows, legal Bt seed in 2005 was 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.

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.

As the proprietary hybrid market expanded, it induced entry from several players which 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 2. 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 (Table 3). 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.

6. Market Leaders: Variation over Time and Space

To look at market leadership over time, we first consider the top 8 firms (according to seed sales in tons adjusted for differential prices between Bt and nonBt seeds) in 1996/97 and 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 4 and 5 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. Thus, 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 accelerated the rapid decline of some firms like Vikram Seeds in Gujarat and been the factor responsible for entry of Navbharat and the consolidation of Mahyco and Rasi in the top ranks.

It is also instructive to examine the regional variation in market shares. We consider the four largest hybrid seed markets: Maharashtra, Gujarat, Andhra Pradesh and Madhya Pradesh. The firms that figure in the top 5 in each of the 4 states are 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 4 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.[6] Thus, there seems to be a minimum of 15 firms with recognizable brands of proprietary seeds.

7. 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 is important in the cotton seed sector. Nor are there home grown "life sciences" firms that have invested in the agricultural end of the business even though their scale would easily allow it. Agri-biotech accounts for less than 10% of the value of Indian biotech industry

[6] The list is indicative and not meant to be exhaustive.

and the largest biotech firm (Biocon Ltd) had revenues more than twice of all agri-biotech.

As for foreign firms, the two significant ones with a presence in the cotton seed industry (and agro-chemicals) are Monsanto and Syngenta.[7] Monsanto has a presence through its equity stake with Mahyco and its joint venture with Mahyco in marketing activities. It is also the 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 include 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.

8. 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 and the following sections is 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

[7] According to press reports, Delta & Pineland, the cotton seed major from U.S. is due to enter the Indian market.

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. However, it is clear from the earlier sections that these barriers have been only modest hurdles. The proprietary seed market has seen entry by a number of firms in the last decade.

9. Entry Barriers: Post-Bt Competition

There are two routes to Bt hybrids. Either a firm can license an already approved gene construct from a technology provider or it can undertake R&D on its own to develop its own Bt gene. Most seed firms in India have chosen the first option of obtaining a Bt gene on license. As noted earlier in Section 4, most cotton hybrids are

based on genes supplied by MMB (Bollgard 1 and Bollgard 2). In this section, we consider the competition in the MMB Bt seeds segment.

If a firm opts for the first route, the principal investments (besides the license fee) by the 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. 1 crore for the biotech lab. In addition, MMB charged a licensing fee of Rs. 50 lakhs in 2005.

While Rs. 1.5 crores is a quantum jump in R&D expenses for most seed firms, the economics of such investment was favourable in 2005 for even a small firm selling 100,000 packets annually. For a packet of seed (450 grams), MMB had fixed a trait value of Rs. 1200 of which Rs. 700 was paid to MMB as royalty (in addition to the lump sum licensing fee of Rs. 50 lakhs) and Rs. 200 to the seed dealer. If the firm expected to sell the seed at Rs. 1600 (the prevailing Bt seed price in 2005), its share of the selling price would be Rs. 700 and its expected revenues would be Rs. 7 crores. As non-Bt hybrids sell for around Rs. 400 per packet, the incremental revenues due to Bt would be of the order of Rs. 3 crores 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. Thus, firms would not have considered the Bt related investments as a barrier to entry and this is borne out by the large number of seed firms that have licensed the Bt gene from MMB.

As it happened though, these assumptions about pricing did not materialize because of the action of the Andhra Pradesh government to impose a ceiling of Rs. 750 on Bt seed. It is not known how this has affected the sharing of royalties on seed sales between MMB and the seed firms that have licensed the seed technology. However, it is clear that even if the seed firm realizes only Rs. 100 (after royalty payments) more than on non-Bt hybrids, the incremental annual flows for a firm selling 100,000 packets would be Rs. 1 crore and would therefore still justify Bt related investments.

Although about 20 firms have licensed Bt genes from MMB, not all the firms 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 were 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 because some of the licensees had just concluded their agreement with MMB and were 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) favoured 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. 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.[8] 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 which included hybrids from 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. In a more recent decision (30th June, 2006), the regulator has waived the requirement of agronomic trials for hybrids with cry 1 Ac gene and in the future for all genes that had been monitored for their performance for three years after their commercialization.

[8] 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.

While the entry of more MMB Bt hybrids offers growers more choices and lessens concentration, the impacts on price would be muted. Because of the revenue sharing agreement with MMB, it is only the share retained by the seed company that could be affected by competition.

10. The Competition between Genes

In 2006, JK Seeds and Nath Seeds won regulatory approval for their Bt cotton hybrids which incorporated non-Monsanto genes. Nath Seeds obtained their Bt gene from the Chinese Academy of Sciences. JK Seeds developed their own Bt genes through collaboration with IIT, Kharagpur. This route is considerably more expensive than licensing it from a technology provider.[9] In addition, the firm also incurs the costs of regulatory compliance. For a firm that licenses an already approved gene, biosafety regulation requires only field trials for agronomic tests. But for a new gene, food and environment safety must also be demonstrated (this requirement applied to hybrids from JK as well as Nath Seeds). In the case of MMB's *cry* 1 Ac gene, the costs of regulatory compliance excluding field trials, amounted to about US $ 1.5 million (or nearly Rs. 7 crores) (Pray, Bengali and Ramaswami, 2005). This is probably an overestimate of what biosafety tests would cost today because many of the tests can now be done in India

The competition from alternative genes could have had 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.

[9] Representatives of JK Seeds would not confirm the exact figure but agreed that the direct costs were in excess of Rs.10 crores. By opting for this route, JK Seeds entered the market much later than its major competitors who licensed Bt genes from MMB. As a result, the indirect costs in terms of the opportunities foregone by not licensing the technology from MMB are probably much larger than the direct costs.

Whether that would happen and to what extent depends 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.[10]

The decision of the Andhra Pradesh government (and then followed by other state governments) to impose a price ceiling of Rs.750 on Bt cotton hybrid seed meant that price competition based on market fundamentals never got to happen. If in the absence of the ceiling, prices would have been above it (as suggested by the fact that Bt cotton seeds are priced at the ceiling rather than below it), then the imposition of the ceiling would have been disadvantageous to the new entrants in 2006 – whether with MMB or other genes. Thus, although the price ceiling was supposedly directed at controlling MMB's monopoly pricing, it probably disadvantaged the alternative gene providers (JK Seeds and Nath Seeds) even more.

11. Illegal Bt and the Seed Market

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

[10] 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.

threat to legal seed, whether Bt or otherwise. In Gujarat, for instance, the market leader Vikram Seeds lost its non-Bt market rapidly because of illegal Bt.

There are several factors that facilitate the spread of illegal Bt seed. Firstly, 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. Second, the illegal Bt coming out of Gujarat is regarded as being of good quality (Herring, 2006; Ramaswami, Lalitha and Pray, 2007; Roy, Herring and Geisler, 2006). 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. Thirdly, 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.

However, there are factors that also constrain the spread of illegal Bt. Most importantly, 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. Second, 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. Third, as the Bt genes come to be incorporated in better adapted hybrids and as improved gene constructs such as Bollgard II are developed, legal Bt could outperform illegal Bt seeds.

12. Concluding Remarks

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. The rapid growth of the proprietary seeds segment subsequently 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. 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. These trends in market structure are consistent with the fact that 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.

With Bt cotton, the seed industry encompasses a seed market as well as a technology market. As of now, the technology market is dominated by Mahyco Monsanto Biotech (MMB) that has licensed its Bt genes 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, 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.

MMB's position as the dominant 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.

For three years starting from 2002, MMB was able to use its monopoly of technology to set Bt seed prices to be four times that of non-Bt hybrids. Even at this price, several refereed studies have estimated that farmers on average have gained substantially from Bt cotton. Using conservative estimates thrown up by this literature, Ramaswami and Pray (2007) conclude that on average growers received about two-thirds of the gains from Bt cotton while the remainder went to the seed company. However, the relatively high price of Bt seeds has drawn adverse attention from NGOs and the government. The trade-off is that while competitive pricing would generate more gains for growers and also greater diffusion, it would also mean that MMB receives no rewards for its technology which could jeopardise incentives for future product development from MMB and other potential technology suppliers.

MMB's monopoly has however, been challenged by illegal seeds, by alternative gene providers and by state policy. Illegal seeds in Gujarat have, by and large, done well

outclassing the MMB hybrids that were initially approved. The social gains from the diffusion of these seeds are likely to have been positive. However, they do undermine the intellectual property of MMB varieties which once again raises the dilemma of how does one preserve the incentives for innovators without restricting the spread of the innovation? Ramaswami, Lalitha and Pray (2007) argue that the appropriate policy response should be mechanisms such as technology buy-outs. Then it is possible for seed prices to be low, diffusion to be unconstrained and for innovators to receive rewards from such spread.

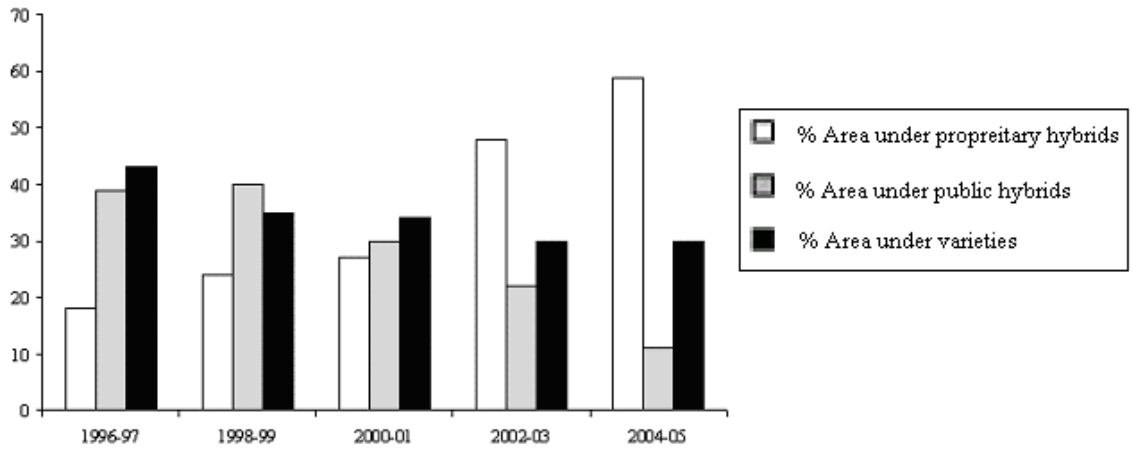
The competition from alternative technology providers is the only sustainable way to reduce the rents of incumbents. The costs of going this route are considerable and would be daunting to any seed firm. Yet, we have two instances of it. Unfortunately, the state policy of price regulation has not allowed the resulting competition to play out. In fact, price regulation has severely disadvantaged the new entrants into the technology market and has probably discouraged future entrants. 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.

Table 1: 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

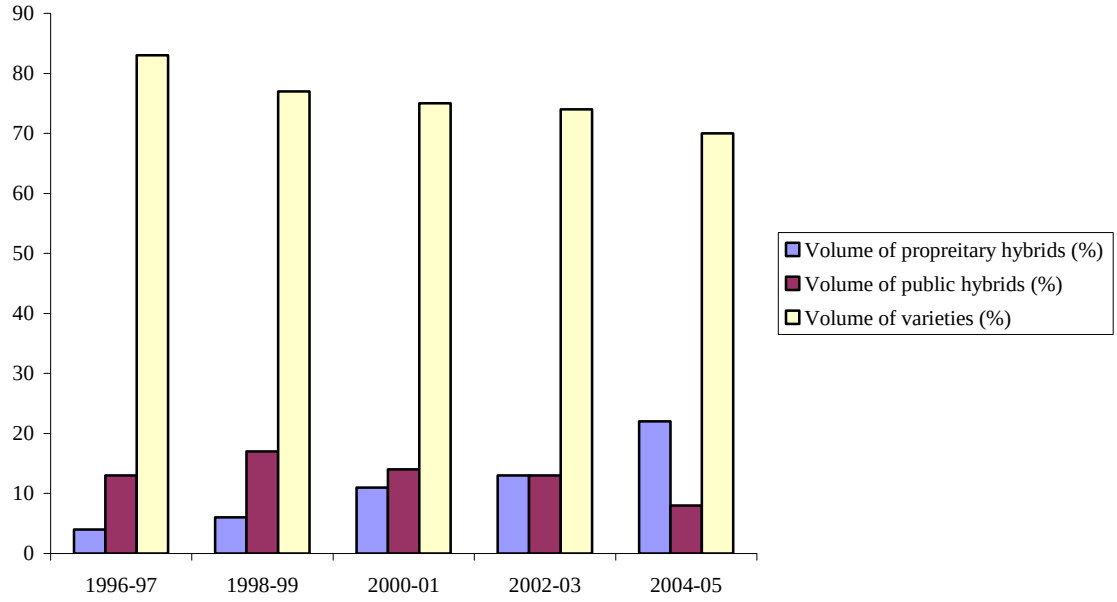
Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 1: Composition of Area under Cotton



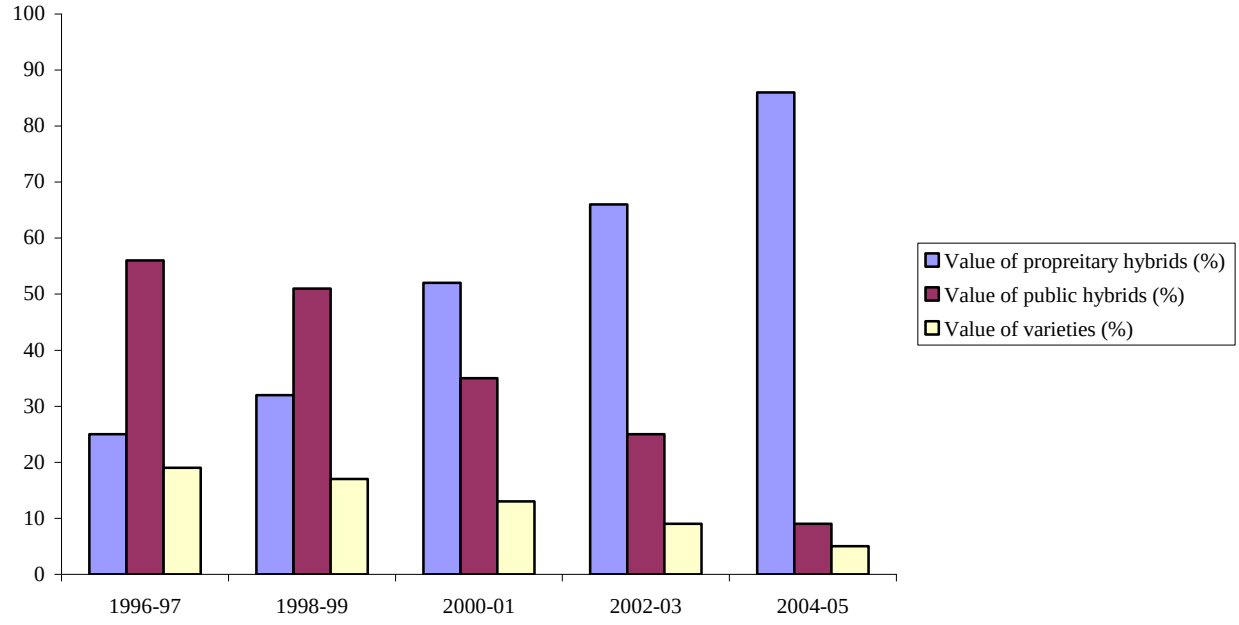
Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 2: Composition of Seed Market by Volume



Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 3: Composition of Seed Market by Value

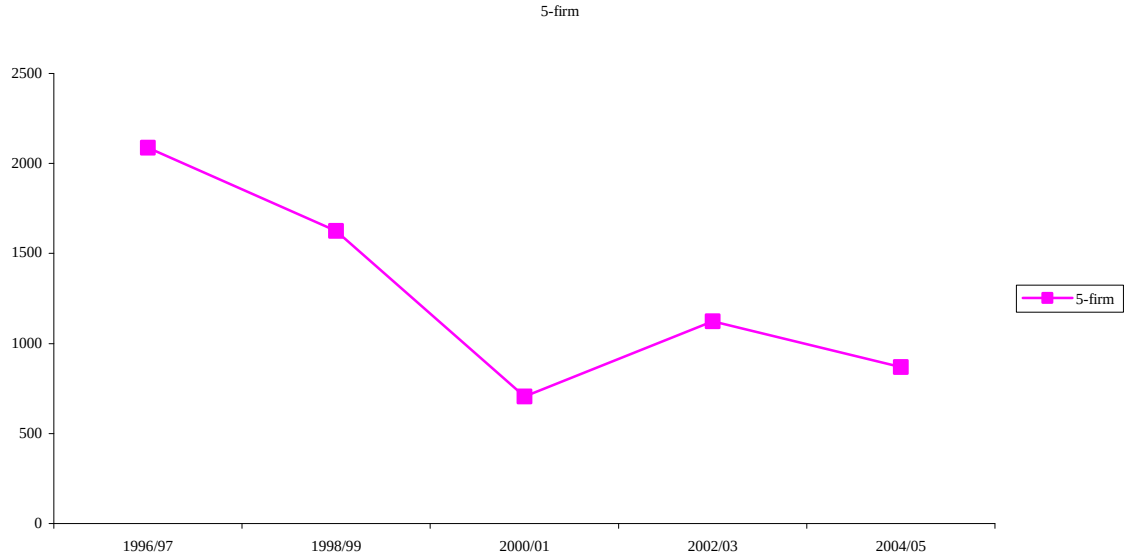


Source: Computed from Francis Kanoi Marketing Research (2005)

Figure 4: Share of top 5 firms in cotton proprietary hybrid seed market

Source: Computed from Francis Kanoi Marketing Research (2005)

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



Source: Computed from Francis Kanoi Marketing Research (2005)

Table 2: 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: 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 4. 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	----

Source: Computed from Francis Kanoi Marketing Research (2005)

Table 5. 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	---	---	---	---

Source: Computed from Francis Kanoi Marketing Research (2005)

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