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The Impact of India's Cotton Yield on U.S. and World Cotton Markets

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Introduction

Cotton is India's main cash crop. It contributes to the livelihood of 60 million people and accounts for 30 percent of the country's agricultural domestic product (Barwale et al., 2004). Total cotton acreage in India is estimated at 9 million hectares, the largest in the world (Gandhi, 2006). About 65 percent of cotton production activities are rainfed and subject to the vagaries of weather. Cotton is grown in nine states, spread over three agroclimatic zones with different planting schedules. Planting usually ends by the first week of June in northern regions (Punjab, Haryana, and Rajasthan), by mid-August in the central region (Gujarat, Maharashtra, and Madhya Pradesh), and by the first week of September in parts of the south (Andhra Pradesh, Karnataka, and Tamil Nadu). A small summer cotton crop in the south (Tamil Nadu) is planted in January and February (FAS, 2006).

While ranking first in cotton planted area, India ranks third in world cotton production behind China and the United States. Indian production levels fluctuate due to the high incidence of crop failure (Gandhi, 2006). Bose (2003) attributed these failures to technical and institutional constraints such as the high cost of pesticides, low-quality seeds, and susceptibility to pest infestation which have continuously plagued cotton production. While there is great heterogeneity in yield distribution across the states, between 100kg/ha in Gujarat and Maharashtra and 430 kg/ha in Punjab and Haryana (Gandhi, 2000), average cotton yields in India are among the lowest in the world. India's average cotton yield in the 2002/03 marketing year of 300 kg/ha was about half of the world average (FAS, 2006b). Cotton producers in India suffer heavy insect infestations with about 50 percent damage compared to 25 percent for the rest of the world (Gandhi, 2000). Equally important, the cost of pesticides to control pest infestations is also high, both monetarily and in terms of environmental impacts. For instance, 54 percent of the 96,000 metric tons of pesticide produced in India are used in cotton production (Gandhi, 2000). For these reasons, the government has sought production alternatives that improve productivity while decreasing the environmental consequences of agricultural practices. An important development in agricultural production that is meeting both these goals is the adoption of Bt cotton.

In 2002 the government approved the distribution of three varieties of Bt cotton in selected regions. The total number of varieties approved for sale was later increased to fourteen in May and June of 2005 (Landes et al., 2005). The incremental adoption approach was designed to avoid any major harm that transgenic seeds may cause to the overall agricultural sector while studying their economic and production performance at the farm level. Numerous studies were conducted in that regard to evaluate whether it would be worthwhile to expand the use of Bt cotton throughout the country. While some of these studies have touted the benefits of Bt cotton, other studies have raised doubts about the effectiveness of Bt adoption to improve farm income, especially for small producers. For instance, the study by Qaim et al. (2006) concluded that Bt cotton adoption led to significant yield gains, considerable reduction in pesticide use, and increased farm income. These findings were corroborated in a study by Bennett et al. (2006) based on farm level survey data in Maharashtra. Overall average impacts were a 34 percent gain

in yield, a 41 percent reduction in chemical cost, a 17 percent increase in total cost, and a 69 percent increase in profit (Raney, 2006). The increase in total cost was due to the higher price of Bt planting seed. While there was some spatial variation in these results, especially in Andhra Pradesh where a 3 percent drop in yield and a 40 percent decrease in profit were observed, by and large the use of Bt cotton has been found beneficial to the Indian cotton sector. Raney (2006) attributed the failures of Bt adoption in Andhra Pradesh to the use of cultivars not suitable to the ecological conditions in that state.

India's cotton production has been dramatically changed in the last two years and the pace of Bt adoption by producers has accelerated. Average yields have increased from 300 kg/ha in 2002/03 to 473 kg/ha in 2005/06, a 57 percent increase (FAS, 2006b). The government of India has approved 20 new Bt varieties for commercial cultivation and Bt cotton planting in MY 2006/07 is expected to jump nearly threefold, to 4.2 million hectares, accounting for half of the expected cotton area (FAS, 2006a).

Cotton plantings have increased in India due to relatively strong cotton prices and better yields. The production increases have enabled India to become a net exporter of cotton. According to the U.S. Department of Agriculture, cotton exports from India in marketing year 2005/06 were 4 million 480-pound bales and 4.2 million bales are estimated for 2006/07 (FAS, 2006b). An interesting question becomes whether this is a sustainable trend in light of the increase of Bt cotton adoption in India. Since India leads the world in cotton planted area, sustained yield gains there would likely have important market consequences. If India were able to achieve cotton yields on par with the rest of the world, the global cotton market would be significantly impacted.

The purpose of this study was to estimate the effects of yield changes in Indian cotton production on the U.S. and world cotton markets. To accomplish this we used a partial equilibrium structural econometric model of the world fiber market developed by the Cotton Economics Research Institute at Texas Tech University. This analysis compares a baseline of cotton production estimates to alternative production scenarios. The baseline in this case was that Indian cotton yields continued to exhibit growth increases consistent with those achieved in the last few years. This rate of increase, about 3 percent per year, would result in an increase in cotton yields from .94 bales per acre in 2007/08 to 1.19 bales per acre in 2016/17. An alternative scenario models a more optimistic rate of yield increase in which Indian cotton yields equal the world average by 2016/17. This optimistic scenario would require a rate of increase of about 5 percent per year and average yields would be 1.56 pounds per acre by the end of the period of analysis. Also modeled is a pessimistic scenario in which Indian cotton yields grow at a much slower rate, one consistent with much longer term average growth rates. In this pessimistic scenario, yields increase at about ½ of one percent per year. In the pessimistic case, yields would increase from .93 bales per acre in 2007/08 to .98 bales per acre in 2016/17. Figure 1 compares the baseline to the two alternative scenarios in the context of the last 25 years of cotton yield averages in India.

Methods and Procedures

The model includes 24 major cotton importers and exporters: Asia (Greater China, India, Pakistan, Taiwan, South Korea, Japan, and other Asia); Africa (West Africa, Egypt, and Other Africa); North America (Mexico, United States, and Canada); Latin America (Brazil, Argentina, and Other Latin America); Oceania (Australia); Middle East (Turkey and Other Middle East); Former Soviet Union (Uzbekistan, Russia, and Other FSU); and Europe (European Union-25 and other Western Europe). A representative country model includes supply, demand, and market equilibrium for cotton and man-made fibers. Area planted to cotton is modeled in a two-stage framework. The first stage determines gross cropping area. The second stage uses economic variables such as expected net returns to allocate area among cotton and competing crops. Similarly, the man-made fiber supply is estimated by modeling capacity and utilization separately. Cotton demand is estimated following a two-step process. In the first step, total textile consumption is estimated and in the second step, allocations among various fibers such as cotton, wool, and polyester (as a representative for man-made fibers) are estimated based on relative prices. The polyester price and cotton A-index price are endogenous and determined by equalizing world exports and imports.

The U.S. model, includes supply, demand, and market equilibrium for raw fibers (cotton and man-made) and textile products (cotton and non-cotton). The inclusion of textile models enables the estimation of cotton and man-made fiber mill use with appropriate linkage between the cotton and textile sectors. On the U.S. supply side, cotton production is divided into four regions: Delta, Southeast, West, and Southwest (irrigated and dry land). Regional production is modeled using separate acreage and yield equations. India planting area and yield is modeled according to four productive regions as well: South, Central, North, and Others.

Data used in this study was compiled from various sources including the Food and Agricultural Policy Research Institute (FAPRI) for the historical and projected macro variables (real GDP, exchange rate, population, and GDP deflator); Production, Supply & Demand (PS&D) database of the Foreign Agricultural Service (FAS) for cotton acreage, yield, production, mill use, ending stocks, and trade; and the FAO World Fiber Consumption Survey and Fiber Organon for fiber mill consumption and man-made fiber statistics.

Simulation Results

The approach used to incorporate changes into the model for simulating India yield changes was to develop a ten-year baseline (2007/08-2016/17). For the simulation, yield changes were increased starting in 2007/08, while the rest of the world was allowed to react to the resulting price signals. The effects were measured by comparing supply, demand, and trade indicators before and after the changes in Indian cotton yields.

Simulation results are reported in Tables 1 through 3 and Figures 2 and 3. Table 1 displays the effects of Indian yield changes on world supply, demand, trade and price. Table 2 summarizes the effects on the U.S. cotton sector. Table 3 reports Indian yield effects on the imports and exports of other major cotton trading nations. In the optimistic scenario, India's cotton production would total 35 million bales in 2016/17, 27 percent above the baseline. In absolute terms, total production would increase 937 thousand bales in 2007/08 and 7.6 million bales in 2016/17. The change in production would lead to an increase in India's cotton exports (see

Figure 2). Total exports would increase from 5.1 million bales in 2007/08 to 13.2 million bales in 2016/17, almost double the baseline. Such gains would firmly place India as a major world cotton exporter. The effects of India's yield gains on world cotton production and mill use are relatively moderate, about a 4 percent increase in each by 2016/17. The effects on world cotton exports are somewhat higher, an 8 percent increase by the end of the baseline. The rise of India as a major cotton exporter would be at the expense of Brazil (whose exports are expected to decline by as much as 24 percent in 2016/17), Australia (with a 7 percent decline), and West Africa (with a 5 percent decline). The U.S. export sector is relatively unaffected under this scenario. Brazil, Australia, and West Africa are more sensitive to the change in world price while U.S. producers are less vulnerable to depressed world prices because of policy provisions of the U.S. farm program¹. In the optimistic scenario, the cotton world price (A-index) is expected to be lower than the baseline by 10 percent in 2016/17 at 62 cents per pound compared to 69 cents per pound (see Figure 4). The increase in total exports is matched with import increases, primarily from China (up 74 thousand bales in 2007/08 and 3.1 million bales in 2016/17).

In the pessimistic scenario, India cotton exports decreased by 43 thousand bales in 2007/08 and by 3.5 million bales in 2016/17. The reduced export volume would lead to an appreciation of the world price by 0.15 percent in 2007/08 and by 5 percent in 2016/17. As a result, exports for Brazil, Australia, and the West African countries increased because of these countries sensitivity to world price. The results indicate that Brazilian exports would increase by 11 percent in 2016/17, followed by the West African countries at 4 percent, and Australia by 3 percent. The U.S. is relatively unaffected by the drop in Indian exports, appreciating by about 1 percent in 2016/17, or about 193 thousand bales.

Summary and Conclusions

This paper analyzed the effect of Indian cotton yield increases on the world cotton market. The results show that the impact of these yield changes vary across countries based on their sensitivity to changes in the world price. Brazil was found to be the most affected by India's rise as a cotton exporter followed by Australia and the West African countries. If India's cotton yield reached the world average by 2016/07, its cotton production would dramatically increase leading to more Indian cotton exports and a lower world cotton price. World cotton production increased only slightly as world exports appreciated indicating export displacements from other countries, mainly Brazil. Overall indications are that while yield gains in India affect countries more responsive to world market fluctuations (such as Brazil, Australia, and the West African countries), they have a minimal effect on countries with substantial market protection instruments in place (such as the United States). However, it appears that changes in India's cotton yields have the potential to dramatically impact the world cotton market.

¹ A major component of U.S. farm policy is to provide income support to agricultural producers in times of low market prices. Thus if Indian cotton yields lower world cotton prices, U.S. producers may not directly feel the impact due to the market insulating effects of U.S. farm policy. With price support mechanisms in place, lower world prices would not necessarily mean lower returns from cotton production for U.S. producers. Therefore the effects on U.S. cotton production and subsequently, U.S. cotton exports may be relatively small. However, Indian yield effects may make a significant difference in the amount of payments the U.S. government makes to cotton producers.

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Table 1. Effects of Indian Yield Changes on the World Cotton Market

		2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
A-index (cents per pound)	Baseline	57.93	62.02	64.04	64.46	64.88	65.91	67.27	68.49	68.85	69.47
	Optimistic	55.36	59.11	60.23	60.49	60.60	61.43	61.77	62.03	62.32	62.40
	Pessimistic	58.01	64.01	68.27	70.87	70.98	72.02	72.06	72.09	72.47	73.12
Indian Production (000 bales)	Baseline	20998.74	21841.61	22818.81	23704.86	24468.66	24907.76	25077.05	25660.9	26476.9	27386.62
	Optimistic	21935.76	23068.59	24261.25	25500.39	26749	28012.19	29476.7	31092.43	33003.73	34964.94
	Pessimistic	20932.64	21123.27	21337.01	21574.87	21786.49	21930.82	22148.37	22383.47	22720.26	23003.37
Indian Exports (000 bales)	Baseline	4601.892	4664.062	5174.046	5450.349	5766.225	5979.479	6040.571	6479.81	6650.272	6778.40
	Optimistic	5089.609	5544.444	6240.624	6823.748	7552.668	8472.969	9571.32	10985.57	12146.52	13182.62
	Pessimistic	4558.55	4267.55	4238.83	4024.42	3757.61	3635.33	3582.17	3713.02	3594.98	3289.32
World Production (000 bales)	Baseline	120925.3	123642.1	125755.6	128005.8	130494.9	132666.2	134338.8	134490.4	137622.5	140444.0
	Optimistic	121807.6	124617.5	126770	129171.8	132102.6	135037.3	137726.5	138737.3	142682	146470.5
	Pessimistic	120804.5	122900.3	124322.4	126100.1	129141.5	130992.5	132503.4	131871.6	133944.1	135701
Exports (000 bales)	Baseline	44631.62	46060.53	47659.87	48570.57	49587.87	50266.9	51225.06	52533.69	54193.87	55268.88
	Optimistic	44966.57	46646.75	48168.53	49112.10	50619.29	51896.03	53630.63	55679.17	57814.31	59555.84
	Pessimistic	44572.83	45814.91	47214.91	48071.92	48736.41	49159.05	49984.12	51029.58	52408.77	53259.21
Mill use (000 bales)	Baseline	122446.4	123916.4	125502.1	127419	129668.9	131982.3	133926	135226.6	137344.5	139547.9
	Optimistic	122989.5	124765.4	126316.8	128248	130861.8	133758	136664.9	138880.7	141911.9	145143.3
	Pessimistic	122387.6	123544.1	124741.2	126351.5	128247	130254.4	131950.9	132718.1	133981.2	135282.5

Table 2. Effects of Indian Yield on the U.S. Cotton Sector

		2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
U.S. Farm Price (cents per pound)	Baseline	47.83	50.11	52.21	53.50	54.95	55.03	55.97	56.89	57.53	58.12
	Optimistic	47.54	49.71	50.74	51.36	51.78	52.94	53.69	53.19	54.18	54.25
	Pessimistic	49.39	53.03	59.83	60.08	61.06	61.29	62.10	63.31	64.26	64.89
U.S. Production (000 bales)	Baseline	23353.77	23197.71	23157.82	23272.97	23287.64	23364.83	23577.15	23846.46	24226.57	24623.02
	Optimistic	23299.04	23149.50	23114.99	23248.22	23218.39	23334.81	23446.42	23623.51	23978.10	24372.90
	Pessimistic	23469.27	23351.25	23408.52	23553.72	23456.20	23450.51	23668.09	23901.16	24269.02	24697.23
U.S. Exports (000 bales)	Baseline	17569.54	18186.13	18394.49	18648.28	18839.83	19037.27	19344.89	19724.16	20229.94	20643.33
	Optimistic	17553.24	18162.22	18356.39	18606.11	18786.59	18972.45	19278.68	19651.06	20164.21	20557.60
	Pessimistic	17570.77	18192.73	18410.68	18704.18	19159.41	19281.88	19386.22	19811.45	20362.13	20836.76
Government Outlays (\$US million)	Baseline	12092.53	12364.21	12575.56	12800.58	13049.49	13266.62	13433.88	13449.04	13762.25	14044.40
	Optimistic	12180.76	12461.75	12677.00	12917.18	13210.26	13503.73	13772.65	13873.73	14268.2	14647.05
	Pessimistic	12080.45	12290.03	12432.24	12610.01	12914.15	13099.25	13250.34	13187.16	13394.41	13570.10

Table 3. Effects of Indian Yield on Major Cotton Exporters and Importers

		2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Major Exporters											
Brazil (000 bales)	Baseline	2316.69	2561.70	2867.34	2961.84	3027.79	3054.25	3203.69	3327.63	3767.67	3905.76
	Optimistic	2282.87	2499.08	2774.25	2833.22	2863.15	2867.15	2891.43	2937.61	2953.96	2959.34
	Pessimistic	2318.32	2581.23	2917.24	3054.21	3168.67	3225.79	3520.87	3643.10	4037.30	4337.18
Australia (000 bales)	Baseline	2842.78	2849.45	2960.93	3086.43	3219.34	3351.72	3477.66	3589.83	3691.57	3766.23
	Optimistic	2805.98	2809.69	2890.87	2990.55	3092.59	3196.56	3281.13	3352.72	3423.03	3488.41
	Pessimistic	2843.94	2874.32	3016.65	3188.57	3353.81	3528.97	3678.75	3797.22	3874.68	3891.91
Western Africa (000 bales)	Baseline	3470.54	3476.06	3508.72	3556.13	3599.79	3642.04	3674.70	3697.75	3705.28	3703.35
	Optimistic	3452.49	3447.00	3459.41	3490.34	3518.04	3546.96	3560.16	3560.40	3547.03	3518.08
	Pessimistic	3471.05	3490.41	3546.36	3627.27	3695.87	3764.39	3809.15	3837.74	3852.39	3859.19
Major Importers											
China (000 bales)	Baseline	21344.86	22711.08	24120.25	24672.23	24956.07	25027.06	25798.80	26784.38	28170.08	29343.85
	Optimistic	21418.67	22965.29	24459.41	25147.60	25788.91	26360.54	27638.65	29076.78	31075.72	32457.41
	Pessimistic	21304.77	22640.73	23975.45	24629.21	24908.93	24936.36	25774.01	26753.67	28138.37	29306.34
Pakistan (000 bales)	Baseline	1808.78	1845.46	1871.93	1832.25	1918.85	2107.79	2206.94	2247.59	2276.36	2101.08
	Optimistic	1803.64	1853.90	1878.60	1845.36	1930.19	2130.03	2267.39	2362.98	2451.91	2388.77
	Pessimistic	1800.23	1841.95	1868.15	1824.20	1886.59	1991.05	2101.76	2146.18	2252.10	2073.11

Figure 1. Indian Cotton Yields under Alternative Scenarios

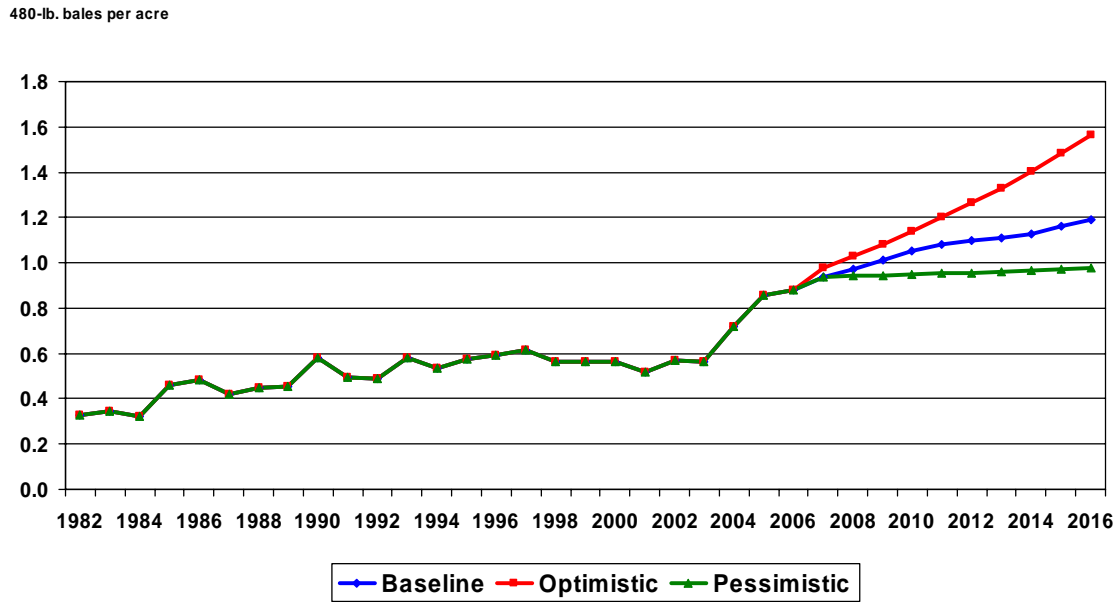


Figure 2. Indian Cotton Exports under Alternative Yield Scenarios

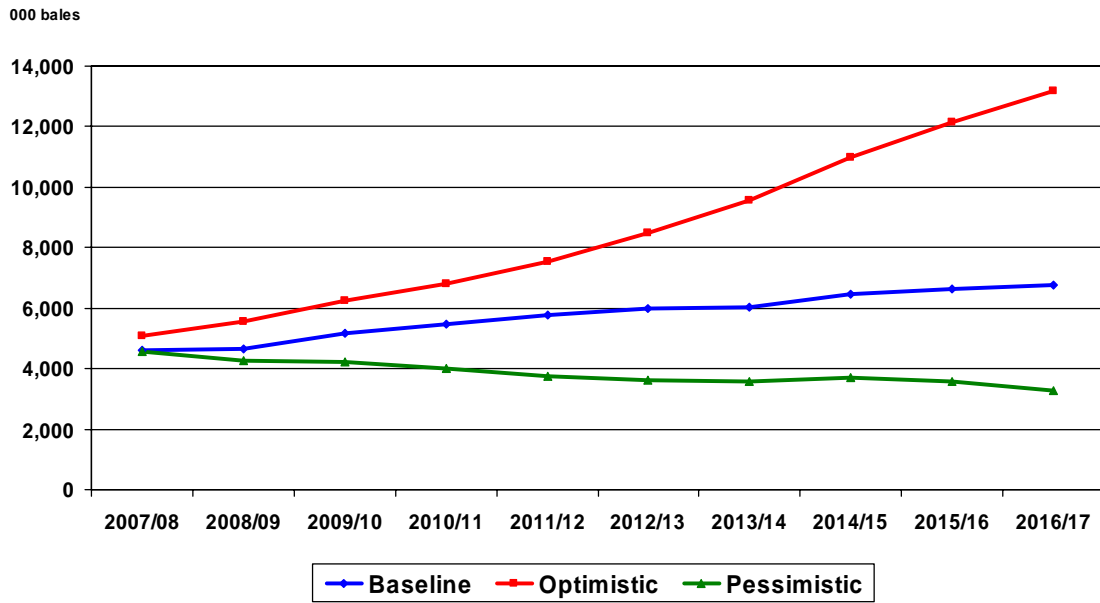


Figure 3. A-index under Alternative Indian Cotton Yield Scenarios

