THE IMPLICATIONS OF REFUGE REQUIREMENTS FOR BT COTTON IN INDIA ON WORLD COTTON MARKETS

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Abstract

The study evaluates the implications of efficient Bt cotton refuge policies in India on world cotton markets. The world fiber model (a partial equilibrium structural econometric model) developed and maintained by the Cotton Economics Research Institute, Texas Tech University was used to measure the impact of changes in refuge requirements in India on world price and trade of cotton. The results revealed that the change in refuge requirements has the potential to impact world cotton markets because India is a large cotton producing country having 25% of world cotton area.

Introduction

India is a major cotton producing country in the world along with the U.S. and China. A change in the supply of and demand for cotton in the Indian market has the potential to have an impact on world cotton trade. In our companion study (Singla et. al., 2010), we examined the profit maximizing refuge requirements (efficient refuge policies) for Bt cotton in the three cotton-growing regions (North, South, and Central) in India. We came up with refuge requirements of 42%, 19%, and 0% for North, Central, and South regions, respectively, for a 15-year time horizon. The major objective of this paper is to evaluate the implications of these efficient refuge requirements in India on the world and U.S. cotton markets. It can be hypothesized that increased refuge requirements for Bt cotton varieties in India could decrease the world supply of cotton because of the lower yield potential of non-Bt cotton varieties planted in refuges. A decrease in world cotton supply could potentially raise world cotton prices, ceteris paribus.

Conceptual Model

The conceptual analysis presented here provides the expected directional change in the world fiber market as Indian cotton farmers comply with efficient refuge policies. It is assumed that the total cotton production under refuge compliance would be less than the scenario where all area is under Bt cotton, provided the refuge requirement is non-zero. It can be hypothesized that higher refuge requirements for Bt cotton varieties in India could decrease the world supply of cotton. Given that the demand for cotton is rising rapidly in India after the elimination of import quotas under the Multi-Fiber Arrangement (MFA), a decrease in supply could have implications for the trade flow of cotton.

A partial equilibrium analysis of a hypothesized cotton trade scenario including India, the U.S., China and the rest of the world (ROW) cotton importing/exporting countries is presented in Figure 1. India and the U.S. are presented as net cotton-exporting countries, implying that domestic supply is greater than the domestic demand for cotton. China is assumed to be a net cotton-importing country.

The conceptual analysis shows that the world price is P_W after considering the Chinese Tariff Rate Quota (TRQ) and the U.S. marketing loan program. The free trade price is shown as P_F. The conceptual model suggests that an increase in the supply of raw cotton in India (as a result of recent increased adoption of Bt cotton) would shift the supply curve from S_I to $S`_I$, which would shift the excess supply curve upward in the world cotton market from S to S_1. This should result in a decrease in world price from P_W to P^1_W and an increase in the quantity traded. It can be inferred that an increase in the world supply of cotton does not necessarily translate into sustained higher revenues/profits for adopters of Bt cotton as prices for cotton could fall worldwide (Bennett et al, 2004; Huang et al, 2002), provided there is not a concurrent increase in demand.

As mentioned earlier, the rising domestic demand for textiles in India because of an increased standard of living in recent years, coupled with increased exports of cotton-based textiles associated with the elimination of import quotas under the Multi-Fiber Arrangement (MFA), could increase demand for domestic and imported cotton in India. In Figure 1, this is represented by the total demand for textiles increasing from T_D to $T`_D$. Due to this increase in demand for textiles, the derived demand for cotton in India is expected to increase from $D_I$ to $D`_I$. This would result in a decrease of the excess supply in the world market from *S1* to *S2*, and an increase in the price from P^1_W to P^2_W, and a decrease in the quantity traded.

If cotton farmers comply with efficient refuge requirements, the supply of cotton is expected to decrease as Bt cotton has significantly higher yield than non-Bt cotton varieties. In Figure 1, this is represented by a decrease in the supply of cotton in the Indian market from $S`_I$ to $S``_I$. A decrease in supply would shift the excess supply curve downward to S_3, resulting in a world price between P_W to P^2_W. However, the net change in world price and trade is and empirical question and can only be determined by the various elasticities of demand and supply involved (Landes et al, 2005).

Methods

The World Fiber model (WFM), developed and maintained by CERI (Cotton Economics Research Institute), Texas Tech was used to measure the impact of a change in the proportion of area under Bt cotton in India as a result of a change in refuge requirements on international trade. The empirical WFM incorporates regional supply response for cotton, substitutability between cotton and man-made fibers, and appropriate linkage between cotton and textile sectors. The WFM includes supply, demand and market equilibrium for the cotton and man-made fibers for the U.S. and 23 other major cotton producing and consuming countries. The model also includes behavioral equations for cotton ending stocks and trade. Tariffs, quotas and TRQs are incorporated into the trade equations. The Cotton A-index and man-made fiber prices are solved in the model by equalizing world imports and exports.

The structural econometric Indian fiber model (a part of the WFM) is schematically represented in Figure 2, depicting the relationship among different components. The model includes supply, demand and price relations for cotton and man-made fibers in India. The model also takes into account the proportions of area under Bt and non-Bt cotton, and yields of both types of cotton. The conceptual analysis suggested that the expected impact of refuge compliance would be to alter cotton trade flows and increase world prices of cotton. The empirical model allows testing this hypothesis as well as the estimation of the magnitude of the change in price and trade flows. The structural Indian fiber model also takes into account inter-fiber competition among cotton, wool and man-made fibers based on their relative prices. Fiber demand is derived by textile consumption and mill demand.

In this study, the baseline projections for supply, demand and prices of cotton, man-made fibers and textiles in the Indian fiber market were obtained from the CERI, Texas Tech. The baseline projections assume that the area under Bt cotton in India would remain fixed at levels for the 2007-08 growing season. Two scenario projections were generated by separating out the yields of Bt and non-Bt cotton using the yield models discussed previously in this chapter. *Scenario1* projections were made by shocking the Indian Fiber model with the efficient (optimal) refuges; whereas *Scenario2* projections were made by shocking the Indian Fiber model by assuming 100% Bt cotton acreage. For both scenarios, the Indian Fiber model was connected to the World Fiber model to estimate the impacts on the world cotton markets. The policy effects were measured by comparing the differences between the scenarios and the baseline projections.

Results and Discussion

This section evaluates the impacts of compliance with a regional efficient Bt cotton refuge policy by farmers in India on world and U.S. cotton markets in terms of both price and trade. The impact under a situation where there is 'no refuge' (i.e. 100% cotton acreage under Bt cotton) was also examined. A partial equilibrium structural econometric model of the world fiber market developed by the Cotton Economics Research Institute at Texas Tech University was utilized to examine these impacts. The structural model first establishes a baseline forecast of the world cotton market along with individual countries and production regions under the current agricultural policy scenario, based on certain macroeconomic assumptions. First, a projection for world cotton markets was developed under the scenario of farmers in India complying with the efficient Bt cotton refuge policy (*Scenario1*), with all other policies and macroeconomic assumptions remaining as in the baseline. Second, a projection for world cotton

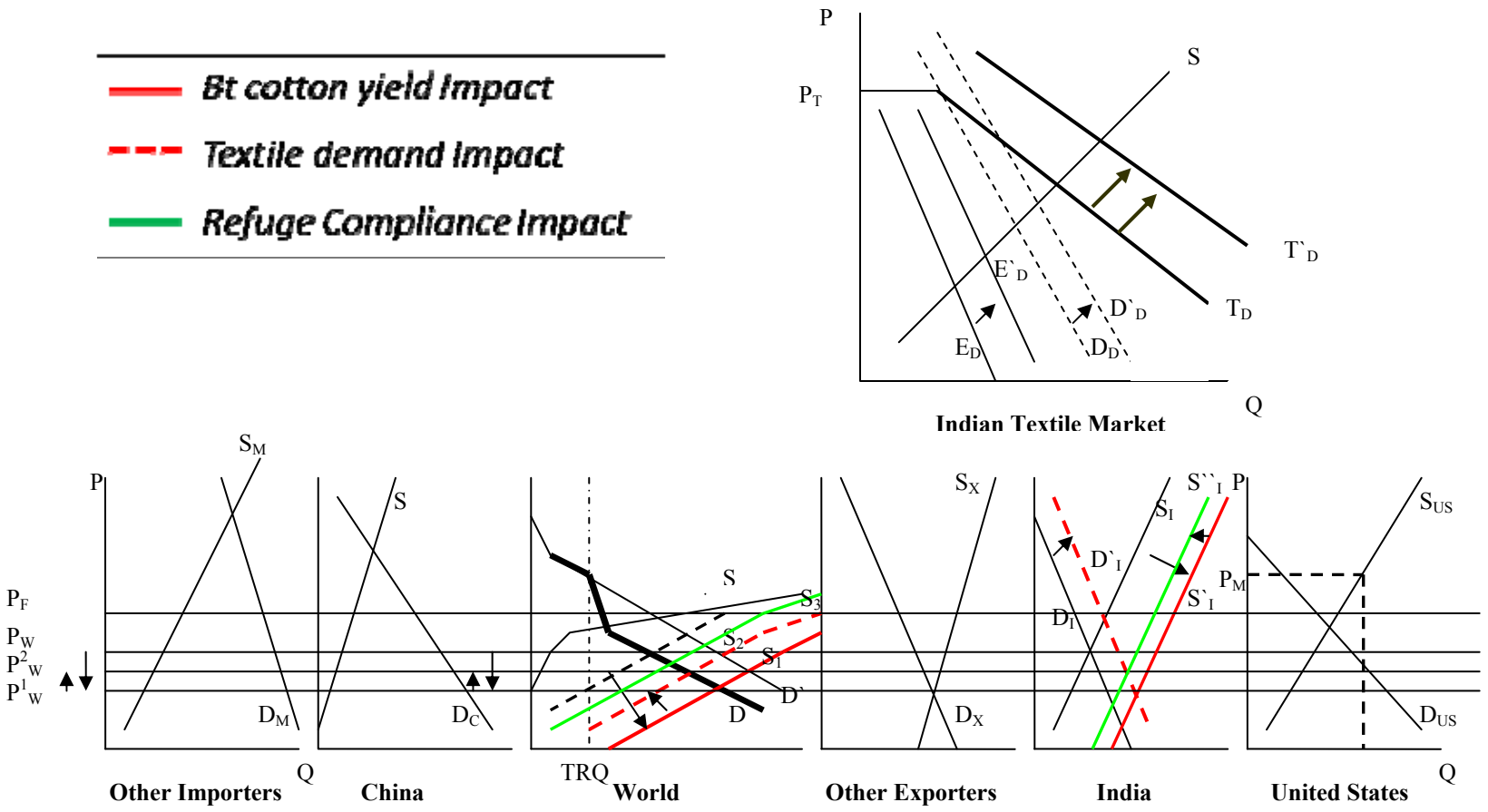

Figure 1. Impacts of Refuge Requirements on the U.S., India and World Cotton Markets

markets was developed under a scenario of Indian cotton growers allocating 100% of their cotton acreage to Bt cotton (*Scenario2*). While making baseline projections, it was assumed that the proportion of Bt cotton grown in India would remain the same as it was in 2007-08. The overall objective here was to develop projections of the impacts of the aforementioned scenarios on the world and U.S. cotton production, consumption, price, and trade.

The impacts of the efficient Bt cotton refuge policy compliance on the world cotton market are shown in Table 1. The top set of numbers represents the world cotton price (A-Index) under the baseline scenario, as well as the projected world price under *Scenario1*. The percentage difference between the two prices shows the relative impact of the efficient refuge policy. For example, in 2008/09 the projected A-Index under the baseline projection was 60 cents/lb, while the projected A-Index under *Scenario1* was 53 cents/lb, a decrease in the world price of 11.53%. This decrease in price is likely because 36.74% of the Indian cotton area was already under refuge (implying that 63.26% was under Bt cotton) in 2007-08. According to the efficient refuge policy, only 19.44% of the cotton area should be under refuge from 2008 onwards (under the fifteen-year planning horizon) potentially resulting in an increase in the area of Bt cotton and hence cotton production. An increase in cotton production in India would lead to an increase in excess supply of cotton in the world and a decrease in the world cotton prices. In the conceptual framework, it was shown that world cotton prices would be expected to decrease if 100% of the cotton area in India would be under Bt cotton. The results under *Scenario2*, where 100% of Indian cotton acreage is under Bt cotton in India are presented in Table 2. Under *Scenario2*, the decrease in world price was greater than under *Scenario1* because of a relatively greater excess supply of cotton (due to 100% of acreage under Bt cotton). The percentage decline in prices (as compared to the baseline) for 2007-08 and on average, respectively, were 11.53% and 4.14% under *Scenario1*; and 23.24% and 8.17% under *Scenario2*. In summary, it can be concluded that the change in structured cotton refuge area in India according to efficient refuge policies would be anticipated to have a significant downward impact on world cotton prices.

U.S. cotton prices showed a similar trend as world cotton prices. The average decrease in the U.S. cotton prices was 3.53% and 7.28% under *Scenario1* and *Scenario2*, respectively (Tables 3 and 4). The average decline was slightly less than that of world markets under both scenarios.

Compared to the baseline, net cotton trade would be expected to increase on an average by 1.71% and 3.49% under *Scenario1* and *Scenario2*, respectively, as shown in Tables 1 and 2. This increase in trade is due to an increase in the excess supply of cotton in the world market, which further reduces world cotton prices.

U.S. cotton exports, on the other hand, are projected to decrease approximately 0.65% under both scenarios as compared to the baseline (Tables 3 and 4). As shown in Tables 1 and 2, world cotton mill use would increase by 0.82% and 2.40% under *Scenario1* and *Scenario2*, respectively, compared to baseline projections. Increase in world cotton production accounted for these increases. The ending stock of cotton in the U.S. is expected to increase by 1.07% and 1.37% under *Scenario1* and *Scenario2*, respectively, as shown in Tables 3 and 4. A possible reason for this could be the expected decrease in exports of cotton from the United States. Tables 3 and 4 also show that there would not be a significant impact on the area, production and yield of cotton in the U.S under both of the scenarios.

Summary/Conclusions

The impact of efficient refuge policies on world cotton markets was estimated by using the World Fiber Model developed by CERI, Texas Tech. The World Fiber Model first establishes a baseline forecast of the world cotton markets under the current market conditions. Two scenarios projections were made by shocking the baseline model. *Scenario1* assumed that farmers in India complied with the efficient Bt cotton refuge policy. *Scenario2* assumed that farmers allocated 100% of their cotton acreage to Bt cotton. The percentage declines in prices (as compared to baseline) on average were 4.14% and 8.17% under Scenario1 and Scenario2, respectively. The average decrease in the U.S. cotton price was 3.53% and 7.28% under Scenario1 and Scenario2, respectively. Compared to the baseline, net cotton trade would be expected to increase on an average by 1.71% and 3.49% under Scenario1 and Scenario2, respectively. The U.S. cotton exports, on the other hand, are projected to decrease approximately by 0.65% under both scenarios as compared to the baseline. It was concluded that the proportion of Bt cotton according to the static optimal refugia has potential to upset the world cotton markets because India is a large cotton producing country having 25% of world cotton area. The results suggest that the Indian farmers' compliance with optimal refugia would increase cotton prices and decrease global net trade (as compared to no refuge requirements in India) of cotton in the world and the United States.

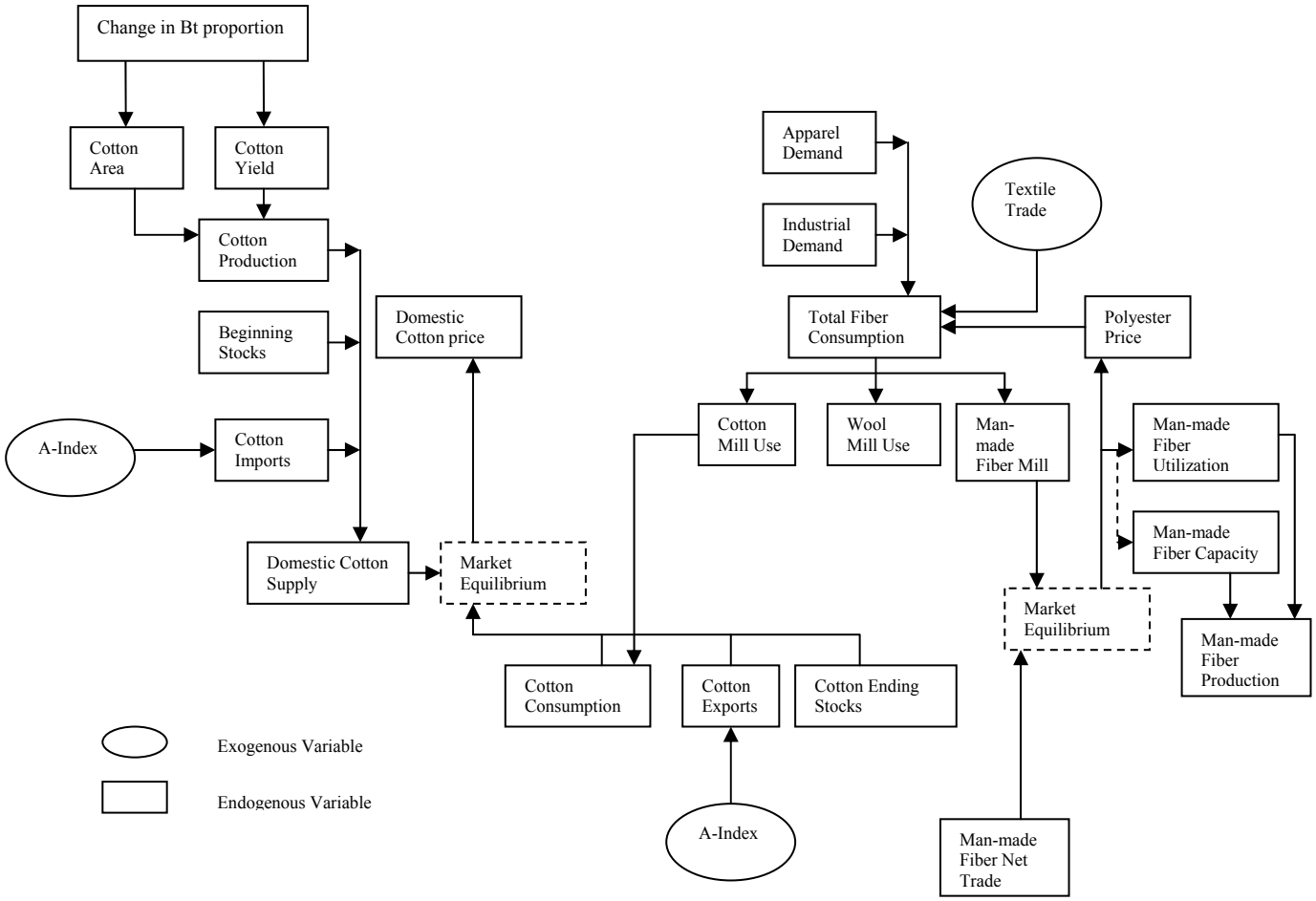

Figure 2. Indian Fiber Model

Table 1. Estimated Effects of Efficient Bt Cotton Refuge Policy Compliance in India (Scenario1) on the World Cotton Markets

		2008/09	2010/11	2012/13	2014/15	2016/17	2018/19	2020/21	2022/23	Avg.
A-Index		----------$/lb----------								
	Baseline	0.6	0.71	0.74	0.75	0.76	0.78	0.83	0.87	0.76
	Scenario	0.53	0.67	0.7	0.72	0.74	0.76	0.81	0.86	0.73
	% Change	-11.53%	-5.08%	-4.65%	-3.62%	-3.00%	-2.99%	-2.49%	-1.34%	-4.14%
Area		----------000 Acres----------								
	Baseline	76883.07	77691.05	80184.08	82030.5	83052.21	84674.68	87578.03	90030	82650.17
	Scenario	76981.52	77096.03	79660.2	81498.51	82552.12	84195.92	87098.02	89609.09	82191.37
	% Change	0.13%	-0.77%	-0.65%	-0.65%	-0.60%	-0.57%	-0.55%	-0.47%	-0.55%
Production		----------000 Bales----------								
	Baseline	109916.7	115051.7	122448.9	129065.4	134585.2	140487.6	149122.3	156631.9	131959.5
	Scenario	111754.2	115724.9	123351	129997.2	135610.2	141626.8	150357.6	158104.8	133050.2
	% Change	1.67%	0.59%	0.74%	0.72%	0.76%	0.81%	0.83%	0.94%	0.83%
Mill Use		----------000 Bales----------								
	Baseline	113746.3	113971	122169.9	127756.4	133660.2	139335.8	147164.2	153447	131219.5
	Scenario	114767.8	114685.8	123063.9	128779.4	134747.9	140519.1	148500.6	155063.8	132307.9
	% Change	0.90%	0.63%	0.73%	0.80%	0.81%	0.85%	0.91%	1.05%	0.82%
Net Trade		----------000 Bales----------								
	Baseline	31463.01	36567.51	40280.88	43171.74	46439.11	48896.98	50802.49	53069.77	43999
	Scenario	31886.77	37118.06	40977.29	43961.74	47268.71	49747.35	51689.47	54081.85	44759.43
	% Change	1.35%	1.51%	1.73%	1.83%	1.79%	1.74%	1.75%	1.91%	1.71%

Table 2. Estimated effects of 100% Bt cotton acreage in India (Scenario2) on world cotton markets

		2008/09	2010/11	2012/13	2014/15	2016/17	2018/19	2020/21	2022/23	Avg.
A-Index		----------$/lb----------								
	Baseline	0.6	0.71	0.74	0.75	0.76	0.78	0.83	0.87	0.76
	Scenario	0.46	0.63	0.67	0.7	0.72	0.74	0.79	0.84	0.7
	% Change	-23.24%	-10.42%	-8.76%	-6.95%	-5.71%	-5.82%	-5.01%	-2.87%	-8.17%
Area		----------000 Acres----------								
	Baseline	76883.07	77691.05	80184.08	82030.5	83052.21	84674.68	87578.03	90030	82650.17
	Scenario	77084.6	76502.92	79131.99	80991.57	82080.22	83749.67	86640.75	89217.04	81752.22
	% Change	0.26%	-1.53%	-1.31%	-1.27%	-1.17%	-1.09%	-1.07%	-0.94%	-1.09%
Production		----------000 Bales----------								
	Baseline	109916.7	115051.7	122448.9	129065.4	134585.2	140487.6	149122.3	156631.9	131959.5
	Scenario	113752.1	116457.6	124215.6	130944.7	136647.3	142797.1	151636.7	159451.3	134164.2
	% Change	3.49%	1.22%	1.44%	1.46%	1.53%	1.64%	1.69%	1.80%	1.68%
Mill Use		----------000 Bales----------								
	Baseline	113746.3	113971	122169.9	127756.4	133660.2	139335.8	147164.2	153447	131219.5
	Scenario	116699	116353.6	124824.4	130664.2	136743.5	142756.8	151021.3	158026.9	134398.4
	% Change	2.60%	2.09%	2.17%	2.28%	2.31%	2.46%	2.62%	2.98%	2.40%
Net Trade		----------000 Bales----------								
	Baseline	31463.01	36567.51	40280.88	43171.74	46439.11	48896.98	50802.49	53069.77	43999
	Scenario	32357.48	37715.07	41683.66	44766.37	48114.07	50612.55	52613.46	55086.42	45547.11
	% Change	2.84%	3.14%	3.48%	3.69%	3.61%	3.51%	3.56%	3.80%	3.49%

Table 3. Estimated effects of efficient Bt cotton refuge policy compliance in India (Scenario1) on the U.S. cotton market

		2008/09	2010/11	2012/13	2014/15	2016/17	2018/19	2020/21	2022/23	Avg.
Farm price		----------$/lb----------								
	Baseline	0.49	0.56	0.57	0.58	0.59	0.62	0.64	0.7	0.59
	Scenario	0.44	0.53	0.55	0.56	0.58	0.6	0.63	0.69	0.57
	% Change	-10.37%	-4.56%	-4.49%	-3.50%	-2.67%	-2.41%	-1.56%	-1.43%	-3.53%
Area		----------000 Acres----------								
	Baseline	7757.96	8054.12	8031.7	8016.15	8034.04	8062.85	7977.74	7976.19	7993.06
	Scenario	7856.41	7958.56	8021.69	8007.78	8027.55	8057.42	7973.45	7973.81	7984.86
	% Change	1.27%	-1.19%	-0.12%	-0.10%	-0.08%	-0.07%	-0.05%	-0.03%	-0.10%
Yield		----------Bales/Acres----------								
	Baseline	1.6911	1.8078	1.837	1.865	1.8941	1.9209	1.939	1.9659	1.8709
	Scenario	1.6881	1.807	1.8357	1.8638	1.8932	1.9201	1.9383	1.9654	1.8699
	% Change	-0.18%	-0.05%	-0.07%	-0.06%	-0.05%	-0.04%	-0.04%	-0.02%	-0.05%
Production		----------000 Bales----------								
	Baseline	13119.76	14560.46	14754.47	14950.24	15217.6	15487.75	15468.63	15680.06	14953.9
	Scenario	13262.45	14380.85	14725.8	14925.05	15197.7	15471.11	15454.77	15671.65	14930.69
	% Change	1.09%	-1.23%	-0.19%	-0.17%	-0.13%	-0.11%	-0.09%	-0.05%	-0.15%
Mill Use		----------000 Bales----------								
	Baseline	4013.93	3998.05	3643.74	3485.33	3383.22	3325.53	2439.57	722.08	3193.19
	Scenario	4008.5	3988.2	3640.52	3489.55	3404.17	3361.86	2502.9	818.98	3217.19
	% Change	-0.14%	-0.25%	-0.09%	0.12%	0.62%	1.09%	2.60%	13.42%	1.64%
Net Export		----------000 Bales----------								
	Baseline	12188.27	10798.55	11210.66	11535.44	11922.84	12236.61	13137.32	15262.97	12107.89
	Scenario	12175.66	10671.78	11187.94	11516.9	11889.63	12185.23	12991.39	14871.51	12021.99
	% Change	-0.10%	-1.17%	-0.20%	-0.16%	-0.28%	-0.42%	-1.11%	-2.56%	-0.65%
End Stock		----------000 Bales----------								
	Baseline	6961.55	6250.87	6042.73	5900.59	5718.93	5528.02	5394.35	5409.67	5870.63
	Scenario	7122.29	6342.3	6127.09	5964.35	5766.51	5569.65	5423.3	5416.68	5935.71
	% Change	2.31%	1.46%	1.40%	1.08%	0.83%	0.75%	0.54%	0.13%	1.07%

Table 4. Estimated effects of 100% Bt cotton acreage in India (Scenario2) on the U.S. cotton market

		2008/09	2010/11	2012/13	2014/15	2016/17	2018/19	2020/21	2022/23	Avg.
Farm price		----------$/lb----------								
	Baseline	0.49	0.56	0.57	0.58	0.59	0.62	0.64	0.7	0.59
	Scenario	0.39	0.5	0.52	0.54	0.56	0.59	0.62	0.69	0.55
	% Change	-21.15%	-10.12%	-8.31%	-6.69%	-5.07%	-4.68%	-3.41%	-0.48%	-7.28%
Area		----------000 Acres----------								
	Baseline	7757.96	8054.12	8031.7	8016.15	8034.04	8062.85	7977.74	7976.19	7993.06
	Scenario	7959.5	7900.27	8004.23	8000	8021.51	8052.45	7969.17	7995.99	7986.99
	% Change	2.60%	-1.91%	-0.34%	-0.20%	-0.16%	-0.13%	-0.11%	0.25%	-0.08%
Yield		----------Bales/Acres----------								
	Baseline	1.6911	1.8078	1.837	1.865	1.8941	1.9209	1.939	1.9659	1.8704
	Scenario	1.685	1.8119	1.8325	1.8627	1.8923	1.9194	1.9376	1.9671	1.8689
	% Change	-0.36%	0.23%	-0.25%	-0.13%	-0.10%	-0.08%	-0.07%	0.06%	-0.08%
Production		----------000 Bales----------								
	Baseline	13119.76	14560.46	14754.47	14950.24	15217.6	15487.75	15468.63	15680.06	14953.9
	Scenario	13411.9	14314.6	14667.5	14901.4	15178.8	15455.5	15440.9	15729.1	14928.7
	% Change	2.23%	-1.69%	-0.59%	-0.33%	-0.26%	-0.21%	-0.18%	0.31%	-0.15%
Mill Use		----------000 Bales----------								
	Baseline	4013.93	3998.05	3643.74	3485.33	3383.22	3325.53	2439.57	722.08	3193.19
	Scenario	4002.99	3979.08	3637.75	3494.2	3425.23	3397.98	2554.44	843.75	3233.28
	% Change	-0.27%	-0.47%	-0.16%	0.25%	1.24%	2.18%	4.71%	16.85%	2.44%
Net Export		----------000 Bales----------								
	Baseline	12188.27	10798.55	11210.66	11535.44	11922.84	12236.61	13137.32	15262.97	12107.89
	Scenario	12163.72	10661.81	11138.87	11497.43	11856.89	12133.16	12996.66	15064.57	12026.77
	% Change	-0.20%	-1.27%	-0.64%	-0.33%	-0.55%	-0.85%	-1.07%	-1.30%	-0.64%
End Stock		----------000 Bales----------								
	Baseline	6961.55	6250.87	6042.73	5900.59	5718.93	5528.02	5394.35	5409.67	5870.63
	Scenario	7289.16	6453.13	6199.46	6022.5	5809.34	5608.58	5388.72	5074.22	5959.68
	% Change	4.71%	3.24%	2.59%	2.07%	1.58%	1.46%	-0.10%	-6.20%	1.37%

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