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China's Cotton Policy and the Impact of China's WTO Accession and Bt Cotton Adoption on the Chinese and U.S. Cotton Sectors

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Keywords
agricultural trade, Bt technology, China and cotton policy, U.S. cotton exports, World Trade Organization, WTO accession

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CHINA'S COTTON POLICY AND THE IMPACT OF CHINA'S WTO ACCESSION AND BT COTTON ADOPTION ON THE CHINESE AND U.S. COTTON SECTORS

Introduction

Changes in China's cotton market, trade behavior, and cotton technology have important implications for U.S. agriculture. Over the last 10 years, the United States has become China's largest supplier of cotton, providing 66.7 percent of its imports in 1994, 67.2 percent in 1995, 41.8 percent in 1996, and 46.4 percent in 1997. China was the world's largest buyer of U.S. cotton in these years. In 1996, China purchased 28 percent of total U.S. cotton exports. Given this importance, a better understanding of the impacts of recent China policy changes and technology trends is crucial for determining the future of U.S. cotton.

China views cotton as a strategic commodity because of its historic importance in clothing its large army, in obtaining foreign exchange, and as a source of state tax revenue. About 200 million Chinese farmers currently produce cotton.

Since the early 1950s, textile exports have accounted for an important share of total export revenues. Revenue from textile exports increased rapidly following the 1978 economic reforms and has expanded more than 17 times in two decades. From 1978 to 2000, revenue from textile exports accounted for around 25 percent of the total export revenue.

Historically China's government has strictly controlled cotton production, marketing, and trade. However, China's application to join the World Trade Organization (WTO) in the mid-1980s, and its subsequent accession in 2001, has meant a loosening of rigid control in recent years and greater reliance on the principles of comparative advantage. The impacts of China's accession on U.S. and world cotton trade and production likely will be large.

An unknown factor that may influence this impact is the extent to which China remains a low-cost producer of cotton. In recent years, cotton production costs have

increased because of an increase in pest control costs. However, these cost increases probably will be reversed as China adopts Bt cotton.

This study provides a review of China's cotton policy and develops a framework to quantify the impact of China's WTO accession and Bt (*Bacillus thuringiensis*) cotton adoption on Chinese and U.S. cotton sectors. We review policy starting in the early 1950s when the Peoples Republic of China was established through more recent market-oriented reforms. The overview focuses on the development of China's cotton marketing policy. We use a Chinese cotton sector model consisting of supply, demand, price linkages, and textiles output equations. A two-stage framework model provides gross cropping area and total area for cotton and major subsitute crops from nine cotton-producing regions in China. Cotton demand, total fiber demand, and cotton share are estimated for each end user. The estimated parameters from the Chinese model are then used with the Food and Agricultural Policy Research Institute (FAPRI) modeling system to simulate various scenarios of China's WTO accession and Bt cotton adoption.

We begin with a review of Chinese cotton policy and then describe the policy impacts of WTO accession and the development of genetically engineered cotton in China. Then, we discuss the model used in the study. Next, we present model simulation results to evaluate the effects of China's WTO accession and Bt cotton adoption on cotton production, consumption, and trade. We conclude by summarizing the study's findings.

An Overview of the Development of China's Cotton Sector Policy

Even after the rural reforms of 1978, cotton remained one of the most heavily planned sectors of the Chinese economy. The development of China's cotton policy was similar to that of other agricultural products, especially grains (Carter and Zhong 1988). However, there are some differences in policies, especially in marketing policies, because of cotton's historic importance in obtaining foreign exchange and in clothing China's large population.

China's cotton domestic policy reforms can be divided into four chronological stages: 1949–54, 1954–85, 1985–99, and 1999–2001. In the first stage (1949–54), market factors determined cotton production and marketing. The second stage (1954–85) is a period characterized by a state-controlled united procurement marketing system. During

the third stage (1985–99), a contracted purchasing scheme replaced the united procurement system and farmers had some freedom in making production and marketing decisions. The fourth stage (1999–2001) saw rapid market-oriented reform. As opposed to the domestic cotton market, cotton trade was strictly controlled by the Chinese government throughout the entire period.

Free Marketing of Cotton, 1949–54

In the first years after the People's Republic of China was established, there was a free market for cotton, and private traders were allowed to participate in cotton marketing. After decades of war, the new government started to reform the old system of private free markets and to reconstruct the national economy. To control the limited supply of basic goods—cotton, grain, coal, steel, and iron—the Supply and Marketing Cooperatives system (SMC), the government procurement agency, was established to purchase cotton and other foodstuffs for the government.

To compete with private traders and to stimulate production growth, the SMC started an advance payment program in some areas in 1950 and extended this practice throughout the country one year later. The advance payment was a kind of interest-free loan, given to cotton producers before planting at 10–15 percent of the total expected value of purchases and deducted from sales at the time of delivery. Combined with other technology and institutional measures, the advance payment significantly stimulated cotton production and ensured delivery to government agencies. By 1952, total cotton production increased to 1.3 million metric tons (mmt), about three times as large as that in 1949, and the quantity delivered to the cooperatives reached 1 mmt, accounting for 77 percent of the total.

Government Unified Cotton Procurement, 1954–85

After a few years of economic recovery, China started its first five-year plan in 1953. In September 1954, facing a shortage of cotton due to higher demand from the rapidly developing textile industry, the government issued a directive to establish "planned cotton procurement." The marketing of cotton was monopolized by the quasi-state agency, SMC, and all free markets were closed. All farmers were assigned compulsory quotas for delivering cotton at administered low prices. SMC controlled the whole

marketing process, from procurement through processing, storage, transportation, and the allocation of cotton to textile industries.

Cotton planting areas were determined by central authorities and allocated to each province, prefecture, county, commune, and finally down to each production team, which was the basic production and accounting unit in the communal system. Under China's planned economic system, the sown-area plan and the procurement quota were used jointly to ensure production and delivery of the specified goods. No matter how far the actual output exceeded the production target, all cotton produced had to be sold to the state agencies except for a small amount (usually one kilogram per capita) that farmers were allowed to keep for their own use. As there were no other ginning facilities, commune-level SMCs were able to exercise complete monopoly power to procure cotton at the administered price. After processing at their subsidized ginning factories, the cooperatives would ship the ginned cotton to the state-run fiber and textile marketing companies. Because delivery from farmers was more or less guaranteed, above-quota premiums were not widely used in cotton procurement. However, advance payment continued to be in effect during this period. The amount of the advance payment was gradually increased to 15–20 percent of the expected total sales in 1963, and to 20–25 percent one year later.

The growth of cotton production was quite significant between 1949 and 1958, as the annual output increased from 0.44 to 1.96 mmt in nine years. The fast growth in cotton production, as well as in most other agricultural production, can be attributed to the general economic recovery, as well as to the production incentives stimulated by some institutional changes such as land reform. However, cotton production dropped to a new low of 0.75 mmt in 1962, mostly a result of the disaster during the "Great Leap Forward" period. After fully recovering to 2.10 mmt in 1965, cotton production stagnated around that level for about ten years. The slowdown in cotton production resulted largely from rigid central planning, poor management and farming practices under the communal system, and compulsory procurement associated with the low administrative price. These institutions could not provide efficient resource allocation or sufficient production incentives, and the output and its growth could not meet the demand or the objective set for economic development. Therefore, changes in policy were inevitable.

The turning point in Chinese social and economic development came in 1978 when agricultural economic reform and more open market policies were formally launched. The most important reform was the institutional change from commune system to the Household Responsibility System (HRS). Under the HRS, land use rights were contracted to individual farmers. The agricultural tax, local levies, and quota obligations previously collectively borne by farmers under the communal system were bound together and attached to the land use right contract.

Besides the institutional change, the other important measures to boost cotton production were price and non-price incentives. The cotton price for the base procured quantity was raised by 10 percent in 1978, compared with less than 4 percent in the previous 15 years. The price was raised another 15 percent in 1979. Producers in the northern region received an additional 5 percent price premium. As well as the increase in procurement price, the central government set 1976–78 averages as the baseline and paid a 30 percent premium to any delivery above the baseline (Han and Feng 1992).

Major non-price economic incentives were subsidized fertilizer and food grains provided to cotton producers. From 1978, producers were entitled to 80 kg of chemical fertilizer for every 100 kg of cotton delivery. In 1979, the central government provided more rationed grain to cotton producers to keep the grain consumption in cotton producing areas at the same level as in neighboring areas.

The combined effect of these institutional and policy reforms was quite remarkable. Cotton production increased from 2.17 mmt in 1978 to 6.26 mmt in 1984.

Contract Purchasing, 1985–99

Because of several years of extraordinary cotton harvests and in order to promote agricultural structure adjustment based on comparative advantage, the Chinese government decided to change the cotton marketing system from a "unified procurement" to a "contract purchasing" arrangement in 1985. The new price for the "contract purchase" was a weighted average of the previous quota and above-quota prices. Farmers could sell their cotton in the free market after they completed their contracted delivery quota.

The new contract purchasing policy was not exactly a business contract in either its context or its implementation. The farmers didn't have negotiating power and were not recognized by the other contract party. The cotton price in the contract was still set by the

government (Ma 1997). In the northern cotton areas, the weight of the previous quota price was set at 30 percent for the new price, and the above-quota weight was set at 70 percent. The respective weights were set at 60 percent and 40 percent in the southern producing areas. This price change implied that in 1985, the marginal price declined by 7 percent in the northern region and by 14 percent in the southern region. The price further declined by more than 2.4 percent in the northern region in 1986. At the same time, food and grain subsidy benefits were also reduced. Without access to other markets, farmers had no choice but to cut their cotton production. As a result, area sown to cotton decreased by 25.6 percent in 1985 and by 16.2 percent in 1986. Total output declined to 4.15 and 3.54 mmt, respectively, for two years.

In response to the sharp decline in cotton production and a supply shortage in 1985 and 1986, the government increased the procurement price and non-price incentives. In 1987, the price in the northern region was returned to its 1985 level, and the price in the southern region was increased by 8 percent, as the weight for the former above-quota price was increased in the new contracted purchasing price. In 1988, a "cotton production support measure" was enacted: a subsidy of 40 yuans per 100 kg was added to the price, which was equivalent to a price increase of about 11 percent. Many non-price incentives, such as subsidized fertilizer, diesel fuel, and food grain, were instituted or re-instituted in the same year. In 1989, the subsidy was replaced with a formal increase in the procurement price, which brought, on average, a 34 percent increase over the 1987 price level. The price was increased again in 1990 by about 30 percent; the total accumulated increase in cotton price between 1987 and 1990 was over 80 percent. As a result, cotton production recovered from the 1986 bottom of 3.54 mmt and climbed to a new peak of 5.68 mmt in 1991.

After 1991, cotton production fluctuated between 4.5 and 3.7 mmt, following the swings in procurement price and other factors, but it never reached its 1991 level. After more than ten years of reform, the government had lost administrative control of cotton production and had to rely on market forces to adjust supply during this period. The government was not successful in using the procurement price efficiently and this resulted in large, unintended fluctuations and cycles in production.

During most of the last five decades, the central government procured and distributed cotton. However, after the late 1970s reforms, provincial governments gradually gained some degree of control of locally produced cotton distribution. Cotton procured at a low administered price proved to be a good source of profit for the local textile industries. For this reason, the provincial government often blocked interregional shipments. This made it more and more difficult for the central government to formulate and implement its production and distribution plans. Therefore, partly because of this situation and partly because of the general trend in the reform, a national cotton market was established in Beijing in 1997. Provincial and local cotton and jute companies, large textile companies, provincial and local textile supply and marketing companies, the China Textile Import and Export Company, and some pre-approved trading companies were allowed to enter the market. The basic idea was to replace the central plan with an administered market in order to improve the efficiency and effectiveness of cotton distribution.

The cotton market reform was aimed at improving cotton distribution between state-owned processing and marketing enterprises; it did not appreciably change cotton procurement at the farmgate level.

Market-Oriented System, 1999–2001

In the 1999 to 2001 period, China made significant changes to its cotton policy that were consistent with an increased market orientation and the general economic and agricultural reform process. The biggest factor affecting change in cotton policy over this period was oversupply. With a large volume of accumulated cotton stocks and rising budgetary outlays for storage and product loss, the government outlays were estimated at 45 billion Chinese renmingbi (RMB) or U.S.$5.4 billion (Fuell 1998). To reduce these costs, a significant cotton marketing reform was launched in 1999. New policies allowed domestic cotton prices to reflect market conditions. Under this reform, although the government still sets a reference price for cotton, this price is not binding. Xinjiang is the only place in China that maintains a floor support price for cotton. Xinjiang is a remote, largely Muslim region with a long history of unrest that made the central government officials extremely sensitive to any changes that may increase instability in the region, including a drop in the price of the region's main cash crop—cotton.

In line with this liberalization process, a national cotton exchange market was established, allowing individual large- and medium-sized state-owned textile firms to purchase cotton directly from growers, the growers association, or the local branches of the SMC.

Cotton Trade Policy

Major barriers for cotton trade include state trading, tightened import licensing procedures, tariffs, value-added tax (VAT), and export subsidies.

The China National Textiles Import and Export Corporation is the sole import and export agency for raw cotton. The state trading system can be used as an instrument to create barriers to trade and to create discrimination among buyers or sellers.

The tariff rate for cotton is relatively low compared to other agricultural products (most-favored nation rate 3 percent, general rate 8 percent in recent years). However, the VAT adds another 17 percent to the cost of imported cotton, although most of the VAT is refundable. China has compensated for Xinjiang's lack of competitiveness by offering large export subsidies and refunds on the VAT for Xinjiang produced cotton and on textiles produced from Xinjiang's cotton.

In summary, China has implemented significant change in its domestic cotton policy over the past two decades. Domestic marketing has changed from a strict government monopoly in the first five-year planning period to a negotiated contract system during the 1985–99 period, and further to a more market-oriented economy in recent years. Cotton production policy was reformed from a rigid area and procurement quota allocation policy to one based on economic incentives and further to a system determined by market forces. Compared to domestic cotton policies, reforms in China's cotton trade have been quite slow and trade remained strictly controlled by the Chinese government through its state trading company until the years leading up to China's accession to the WTO.

China's World Trade Organization Accession and the Spread of Genetically Engineered Cotton in China

China first applied to join the General Agreement on Tariffs and Trade (GATT), and its successor, the WTO, in 1986. A major step toward securing China's entry into the WTO was made when China signed an agreement with the United States on November

15, 1999. After 15 years of negotiations, China finally joined the WTO in December of 2001. China's inclusion in the WTO has been a significant trade issue for U.S. agriculture and is viewed as benefitting U.S. farmers overall. China promised to cut the currently prevailing average tariff rates from 22 percent to 17.5 percent for agricultural products based on its bilateral agreement with the United States. For cotton, China committed to establishing tariff rate quotas (TRQs) starting at 740 thousand metric tons (tmt) in 2002 and increasing to 890 tmt by 2006 (Table 1). The within-quota tariff on cotton imports will decrease from 3 percent to 1 percent. The out-of-quota tariff on cotton will decline from 76 percent to 40 percent in five years. China agreed to eliminate cotton export subsidies when it joined the WTO, which should benefit U.S. agricultural products competing in third-country markets. Moreover, 67 percent of the TRQ will be reserved for non-state trading enterprises for cotton.

Demand for cotton is a derived demand, determined by the demand for textiles. China is a large exporter of textiles and apparel; exports reached $52.1 billion in 2000, up 21 percent from 1999. Textiles and apparel may benefit more than any other industry from China's accession to the WTO. Several studies that analyze the impact of China's accession using computable general equilibrium (CGE) models (Wang 1997; Ianchovichina, Martin, and Fukase 2000; Li and Zhai 2000; RCRE 1999) indicate that China's trade and production of textiles and clothing will expand rapidly with accession.

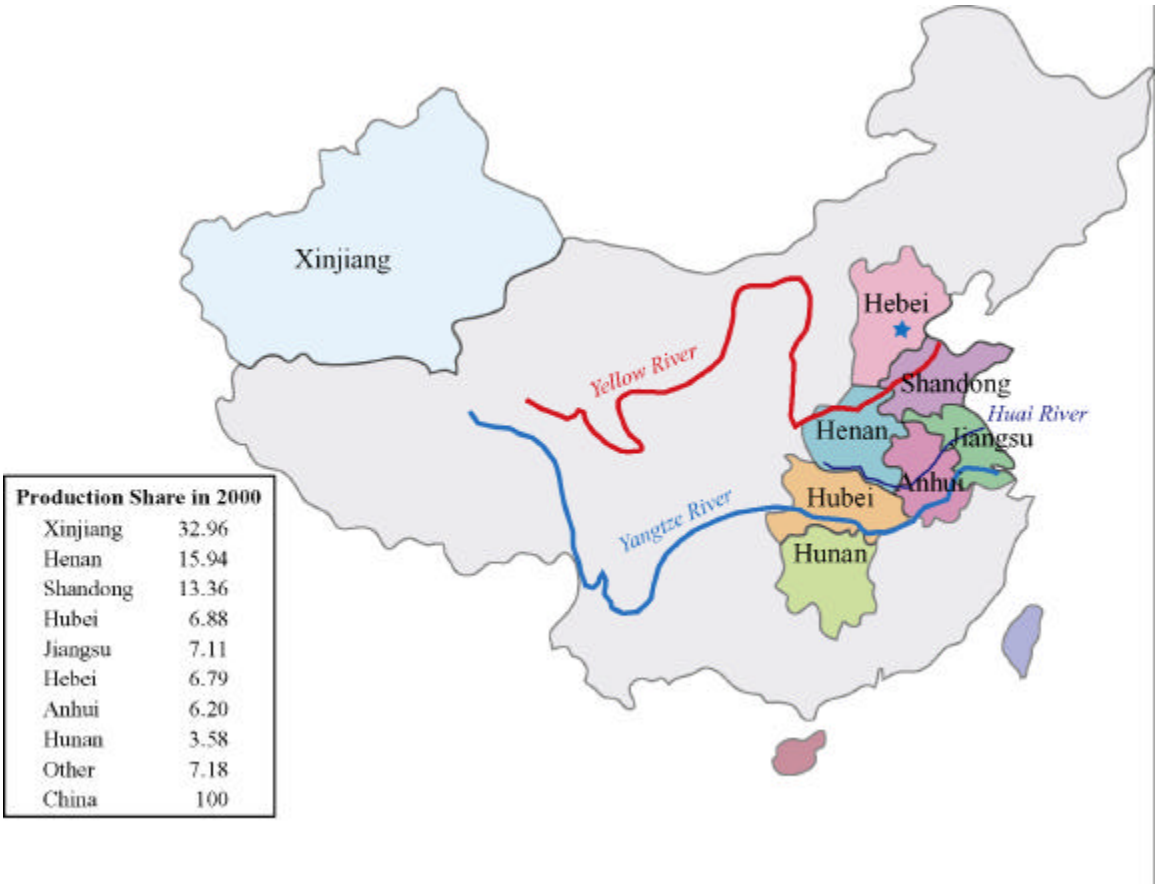
There are about 200 million farmers engaged in cotton production in China. The major cotton producing areas can be divided into three regions (Hsu and Gale 2001): the Yellow River valley, the Yangtze River valley, and the Northwest. The Yellow River

TABLE 1. Trade policy changes for cotton

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Baseline Tariff	3	3	3	3	3	3	3	3	3
Scenario In-Quota Tariff	1	1	1	1	1	1	1	1	1
Scenario Out-Quota Tariff	76	67	58	49	40	40	40	40	40
Scenario Quota Level (tmt)	740	780	820	860	890	890	890	890	890

region covers the northern China plain, extending south from the Great Wall in the north to the Huai River that flows through central Jiangsu and Anhui provinces. The Yangtze River area includes the Qinling Mountains in the north and the Huai River in the south. The northwest region encompasses primarily the Xinjiang autonomous region and northwestern Gansu province. Cotton is produced mainly in eight provinces: Xinjing, Henan, Shandong, Hubei, Jiangsu, Hebei, Anhui, and Hunan. In 2000, these eight provinces produced about 93 percent of China's cotton (Figure 1).

Land devoted to cotton in China declined in the 1990s, the most dramatic being in the eastern part of the country. One of the major reasons for the decline was a significant bollworm infestation, which is costly to control. The frequency of pest outbreaks in the cotton sector doubled within the last ten years (Colby 1995; Huang et al. 2001). Over the



Production Share in 2000	
Xinjiang	32.96
Henan	15.94
Shandong	13.36
Hubei	6.88
Jiangsu	7.11
Hebei	6.79
Anhui	6.20
Hunan	3.58
Other	7.18
China	100

FIGURE 1: China's (mainland) cotton-producing regions

past two decades, per hectare pesticide expenditures in cotton production rose sharply. Based on the State Economic Planning Commission of China's cost-of-production survey data, the per hectare pesticide cost reached 835 yuan in 1995 for cotton, much higher than that for rice, wheat, and corn. The rate of increase in pesticide use in cotton production rose much faster than other inputs. As a result, the share of pesticide expenditure in total material cost of production increased from 11.5 percent in 1985 to 21.7 percent in 1995 (Price Bureau of China, various). Per hectare pesticide costs were much higher in the major cotton producing provinces in east China: 1,703 yuan in Hebei, 1,264 yuan in Shandong, 1,067 yuan in Henan, 798 yuan in Jiangsu, and 774 yuan in Anhui in 1995, which accounts respectively for 46 percent, 31 percent, 36 percent, 26 percent, and 27 percent in each province's total material cost of production in 1995 based on the same survey data.

Adoption of genetically engineered crops with traits for pest management has risen dramatically since their commercial introduction in the mid-1990s. By 1998, around 40 percent of U.S. cotton acres were planted to genetically engineered varieties (Fernandez-Cornejo and McBride 2000). The most widely used pest management traits are herbicide tolerance and insect resistance. Insect-resistant crops contain a gene derived from the soil bacterium *Bacillus thuringiensis* (Bt). The Bt gene allows plants to produce a toxin to protect them from certain insects. Farmers using Bt cotton can reduce insecticide costs by discontinuing or decreasing applications of chemical insecticides targeting certain insects such as the cotton bollworm. It has been shown that adoption of Bt cotton significantly increases yields and net returns and significantly reduces insecticide use (Du 2001; Fernandez-Cornejo and McBride 2000).

Since the late 1980s, Chinese scientists have followed the lead of researchers in the United States and other countries in developing genetically engineered crops with traits for pest management. To battle against cotton bollworm, the Chinese government approved the commercial use of Bt cotton varieties in 1997 (Huang et al. 2001). Varieties of Bt cotton from international companies (mostly Monsanto varieties) and domestic research institutes have been used in several provinces in China. Huang et al. (2001) estimated the Bt cotton area at 700 thousand hectares in 2000; other researchers estimated an even higher area—up to 1 million hectares in 2000 (Vorman 1999; Pray et al. 2001)

and 1.72 million hectares in 2001 (Cai 2001). Data collected by the Center for Chinese Agricultural Policy (CCAP) on 282 cotton farmers in 1999 show that adoption of Bt cotton varieties leads to a significant decrease in the use of pesticides. Per hectare pesticide use with non-Bt cotton production is more than five times higher than that with Bt cotton. Bt cotton costs are 20 to 33 percent lower per pound than non-Bt cotton costs (Pray et al. 2001)

Econometric Model and Estimation of China's Cotton Sector

China's cotton sector is modeled in a comprehensive supply and demand framework. Major components of the cotton model include a supply sector, a demand sector, price linkage equations, and a textile output equation.

The supply of cotton is projected for each of nine cotton production regions. The regions are Xinjing, Henan, Shandong, Hubei, Jiangsu, Hebei, Anhui, Hunan, and Other. Each region has an area equation, a yield equation, and a production equation.

Cotton Area Equations. Area sown to cotton is modeled in a two-stage framework. The first stage determines gross cropping area. The second stage uses economic variables to determine cropping patterns (area allocation) for cotton and major substitute crops.

The gross cropping area ($GCAR_{it}$) is determined by multiplying the arable land (AL_{jt}) by the multi-cropping index (MCI_{jt}):

$$GCAR_{jt} = AL_{jt} \times MCI_{jt} \tag{1}$$

where Al_j is estimated as a function of gross domestic product (GDP), and the multi-cropping index is determined based on major output and input prices.

An acreage allocation model developed by Barten and Vanloot (1996) and modified by Holt (1998) is used to estimate China's cotton production regions' area equation system. The area ($ARCT_{it}$) allocated to cotton is determined by expected cotton net return ($ENRCT_{jt}$) and its major competing crops' expected net return ($ENROC_{ijt}$) for each crop i:

$$ARCT_{jt} = f(ENRCT_{jt}, ENROC_{ijt}) \tag{2}$$

It is assumed that farmers calculate per hectare net returns for each possible crop and then choose the crop with the highest net returns subject to policy constraints. The net

return calculation for each crop is endogenous to the model. It is calculated as expected gross revenue (EGR_{ijt}) less expected input costs (EIC_{ijt}) for crop *i*:

$$ENR_{ijt} = EGR_{ijt} - EIC_{ijt}. \tag{3}$$

The expected gross revenue per hectare is calculated by multiplying the expected producer price (EPP_{ijt}) by the expected yield (EYD_{ijt}):

$$EGR_{ijt} = EPP_{ijt} \times EYD_{ijt}. \tag{4}$$

The EPP_i is the weighted producer price of the free market price (lagged on year) and the procurement price (current year). If policy prices are having a small effect on the crop, then the expected price will depend on the market. For example, cotton prices in 2000 and 2001 were determined by free market prices. Otherwise, the government procurement prices are major factors determining the producer prices.

Expected yield is used to measure output per hectare and is based on the six-year moving average yield after removing the highest and lowest ones. It is constructed by using the following formula:

$$EYD_{ijt} = \tfrac{1}{4}\left[\sum_{k=1}^{6} YD_{ijt-k} - \max(YD_{ijt-1},\ldots,YD_{ijt-6}) - \min(YD_{ijt-1},\ldots,YD_{ijt-6})\right]. \tag{5}$$

Expected input costs are calculated as the sum of expected input prices multiplied by the per hectare application or use rate for each input m:

$$EIC_{ij} = \sum_m (EP_{ijm} \times EQ_{ijm}). \tag{6}$$

Cotton Yield Equations. The cotton yield ($YDCT_j$) is projected for each of the nine production regions. The yield is specified as a time trend based on the last 20 years' yield level and policy variables (*PV*). Bt adoption is assumed as a shifter, and yield is recalculated for the simulation for the Bt adoption based on the adoption rate and assumed yield improvement by Bt cotton:

$$YDCT_{jt} = f(trend, PV). \tag{7}$$

Cotton Production Equations. Next, total production of cotton ($PRODCT_{jt}$) can be defined as the product of area harvested and yield:

$$PRODCT_{jt} = ARCT_{jt} \times YDCT_{jt}. \tag{8}$$

Total Cotton Consumption Equation. After two decades of rapid development, China has emerged as the world's largest producer of chemical fiber. Since 1997, consumption of chemical fiber has grown rapidly and has overtaken that of cotton. The share of cotton in total fiber consumption has declined from 83 percent in 1982 to about 40 percent in 2000 (Fang, Colby, and Babcock 2001).

Fiber consumption can be separated into mill use and non-mill use. Mill demand for fiber is determined by textile output, while non-mill demand for fiber is driven primarily by industrial use. In the last two decades in China, use of non-mill fiber has increased much more than that of mill fiber. The share of non-mill fiber use in total use rose from 25 percent in 1981 to 47 percent in 2000. Cotton shares of total fiber consumption are completely different for mill and non-mill users, with the share in mill use much higher. In 2000, the cotton share in mill use is 64 percent, while the cotton share in non-mill use is about 12 percent. Given these differences, cotton demand DCT_t is estimated and projected separately for mill use and non-mill use in this study. Total fiber demand and cotton share are estimated for mill use and the total cotton demand equation is used for non-mill cotton use.

Total fiber demand in mill use is derived from yarn output ($OYARN_t$) multiplied by the technical coefficient between yarn and fiber. Yarn output is specified as a function of the textile price index (TPI_t) and real GDP_t in China:

$$OYARN_t = f(TPI_t, GDP_t). \tag{9}$$

Cotton share in mill use ($MUSCT_t$) is determined by a price ratio of cotton to man-made fibers ($RTPP_t$):

$$MUSCT_t = f(RTPP_t). \tag{10}$$

Non-mill cotton use ($NMUCT_t$) is estimated as a function of GDP and cotton price ($PPCT_t$):

$$NMUCT_t = f(GDP_t, PPCT_t). \quad (11)$$

Cotton Ending Stock Equation. Cotton ending stock (SCT_t) is specified as a function of lagged ending stock, cotton production, and the domestic cotton price:

$$SCT_t = f(SCT_{t-1}, PRODCT_t, PPCT_t). \quad (12)$$

Cotton Export Equation. Cotton export ($EXCT_t$) is determined by the world cotton price ($PWCT_t$), which is taken from the CIF Northern Europe Cotlook A index in this study, domestic cotton price ($PPCT_t$), and cotton production ($PRODCT_t$):

$$EXCT_t = f(PWCT_t, PPCT_t, PRODCT_t). \quad (13)$$

Cotton Import Identity. Cotton import ($IMCT_t$) is treated as residual to close the model. The import variable is the residual of total demand (consumption, ending stock, export) net of the sum of production and beginning stock:

$$IMCT_t = DCT_t + SCT_t + EXCT_t - CTPROD_t - SCT_{t-1}. \quad (14)$$

Price Transmission Equation between China Cotton Producer Price to Reference Price. China's cotton producer price is linked to the world cotton price by a transmission equation in which the domestic cotton price is specified as a function of the reference price and beginning stock:

$$PPCT_t = f(REFP_t, SCT_t). \quad (15)$$

The cotton reference price ($REFP_t$) is calculated based on the following equation:

$$REFP_t = PWCT_t(1 + TR_t) \times EXCH_t \quad (16)$$

where TR_t is the tariff rate and $EXCH_t$ is the exchange rate between the U.S. dollar and the Chinese yuan.

Price Transmission Equation between Regional Cotton Producer Prices and National Cotton Price. The price transmission equation between regional cotton producer prices and the national cotton price is assumed to have perfect elasticity.

Data used for the area equation cover the period from 1981 to 2000. The data on cotton production, cotton consumption, cotton stock, cotton export, and cotton import are from various issues of the *China Statistical Yearbook* (NBS various) and from the U.S. Department of Agriculture's Production, Supply and Distribution (PS&D) data (USDA n.d.). The data on yarn output are from *China Industrial Economic Statistical Yearbook* (NBS various) and the *Almanac of China's Textile Industry* (Editorial Board of the Almanac of China's Textile Industry 2000). The data on the cotton producer price and the cost of production are collected from various issues of the *China Rural Statistical Yearbook* (NBS various) and various issues of China's *Cost and Return of Production Statistic Materials* (Price Bureau of China various). The world cotton price is obtained from the FAPRI database (FAPRI 2001).

All behavior equations were estimated using the SAS package; estimated results are not reported here but are available from the authors upon request.

Scenario Assumptions and Simulation Results

The estimated econometric models in the previous section are connected to the FAPRI model system to simulate various scenarios of China's WTO accession and Bt cotton adoption. The FAPRI modeling system is a multi-market world agricultural model. The model is extensive in both its geographic and commodity coverage. The modeling system is organized into modules according to major commodity groupings (grains, other crops, oilseeds, livestock, and dairy) with country sub-models. The system captures important linkages between grain, cotton, oilseeds, and livestock markets. Cotton world price is solved by equating excess supply and demand in the world market.

Based on the results of CGE studies, we assume a textile production increase of 20 to 30 percent above the baseline from 2002 to 2007 with WTO accession. The adoption rate of Bt cotton is assumed to increase to 80 percent for all regions except Xinjing in four years—from 2002 to 2006 for the case of the adoption scenario. The cost of production is assumed to fall by 25 percent and yield is assumed to rise by 1 percent under the Bt adoption scenario. We ran

simulations using the following scenarios:

1. With Bt cotton adoption, excluding WTO accession
2. WTO accession with a 20 percent increase in yarn production, excluding Bt cotton adoption
3. WTO accession with a 30 percent yarn production increase, excluding Bt cotton adoption
4. With Bt cotton adoption and WTO accession with a 20 percent yarn production increase
5. With Bt cotton adoption and WTO accession with a 30 percent yarn production increase

Tables 2 through 6 summarize the results for the five scenarios with comparisons to 2001 FAPRI baseline levels and percentage changes from the baseline. The results in Table 2 show that when only the Bt adoption scenario is used without the WTO accession scenario, domestic and world cotton prices decline roughly 0.4 percent for both the Chinese domestic price and for the world price on average during the period 2002–10. Both domestic and world cotton prices in China rise under all other scenarios. WTO accession alone causes the cotton price to climb between 14.3 and 22.1 percent in China and between 7.3 and 11 percent in the world market. The higher domestic price increase relative to world price growth is due to the fact that the cotton import value is binding under the scenarios but is not binding under the baseline. The net effects of the combination of Bt adoption and WTO accession lead to a cotton price increase of between 13.2 and 21.1 percent in China and between 6.9 and 10.5 percent on average for the scenario period.

The impacts on China's cotton area and production are reported in Table 3. The results indicate that Chinese cotton area increases under all five scenarios. As a result of the technology and higher prices, China's cotton area expands on average between 3.0 and 4.4 percent during the simulation period. The increase in cotton area mainly resulted from cotton price increases due to China's accession to the WTO. When only Bt adoption is assumed, the area increases by 0.5 percent in response to the reduction in the cost of production. Cotton yield increases by 0.4 percent under the Bt adoption scenario, but there is no big impact from WTO accession.

TABLE 2. Impact on China's cotton price and world cotton price

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
China's Cotton Producer Price (Chinese Yuan per Metric Ton)										
Baseline[a]	10986	11741	12421	12905	13288	13651	14044	14432	14731	13133
Bt and no WTO[b]	10986	11717	12378	12852	13215	13564	13969	14370	14666	13080
No Bt and 20%[c]	11422	12450	13963	14964	15973	16055	16549	16931	17238	15061
No Bt and 30%[d]	11647	13228	14987	16088	17344	17248	17727	18178	18480	16103
Bt and 20%[e]	11429	12422	13840	14844	15803	15851	16348	16729	17028	14921
Bt and 30%[f]	11647	13151	14890	15965	17185	17069	17548	18007	18298	15973
(Scenario Over Baseline)										
Bt and no WTO	1.000	0.998	0.997	0.996	0.995	0.994	0.995	0.996	0.996	0.996
No Bt and 20%	1.040	1.060	1.124	1.160	1.202	1.176	1.178	1.173	1.170	1.143
No Bt and 30%	1.060	1.127	1.207	1.247	1.305	1.264	1.262	1.260	1.255	1.221
Bt and 20%	1.040	1.058	1.114	1.150	1.189	1.161	1.164	1.159	1.156	1.132
Bt and 30%	1.060	1.120	1.199	1.237	1.293	1.250	1.250	1.248	1.242	1.211
World Cotton Price, Cotlook A Index CIF Northern Europe (U.S. Dollars per Metric Ton)										
Baseline	1533	1544	1566	1588	1607	1626	1645	1667	1691	1607
Bt and no WTO	1533	1541	1560	1581	1598	1614	1635	1659	1682	1600
No Bt and 20%	1595	1640	1684	1718	1764	1750	1770	1790	1817	1725
No Bt and 30%	1626	1677	1725	1783	1851	1818	1835	1861	1885	1785
Bt and 20%	1595	1636	1679	1711	1754	1739	1760	1781	1807	1718
Bt and 30%	1626	1674	1720	1775	1839	1806	1824	1851	1875	1777
(Scenario Over Baseline)										
Bt and no WTO	1.000	0.998	0.996	0.995	0.994	0.993	0.994	0.995	0.995	0.996
No Bt and 20%	1.040	1.062	1.076	1.082	1.097	1.076	1.076	1.074	1.074	1.073
No Bt and 30%	1.061	1.086	1.102	1.122	1.151	1.118	1.115	1.116	1.115	1.110
Bt and 20%	1.041	1.060	1.072	1.078	1.091	1.070	1.070	1.068	1.069	1.069
Bt and 30%	1.061	1.084	1.098	1.117	1.144	1.111	1.109	1.111	1.109	1.105

[a] Baseline: no Bt cotton and no WTO assumption.
[b] With Bt cotton and no WTO assumptions.
[c] With no Bt cotton and 20% increase over baseline in yarn output.
[d] With no Bt cotton and 30% increase over baseline in yarn output.
[e] With Bt cotton and 20% increase over baseline in yarn output.
[f] With no Bt cotton and 30% increase over baseline in yarn output.

TABLE 3. Impact on Chinese cotton production

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
					Area Harvested (1,000 Hectares)					
Baseline	4151	4189	4229	4267	4300	4332	4364	4395	4426	4295
Bt and no WTO	4151	4196	4241	4284	4325	4363	4395	4428	4461	4316
No Bt and 20%	4151	4229	4288	4384	4449	4517	4530	4565	4594	4412
No Bt and 30%	4151	4250	4350	4455	4522	4600	4605	4638	4670	4471
Bt and 20%	4151	4236	4300	4395	4466	4537	4551	4586	4616	4426
Bt and 30%	4151	4256	4357	4468	4539	4620	4626	4660	4693	4485
					(Scenario Over Baseline)					
Bt and no WTO	1.000	1.002	1.003	1.004	1.006	1.007	1.007	1.008	1.008	1.005
No Bt and 20%	1.000	1.009	1.014	1.027	1.034	1.043	1.038	1.039	1.038	1.027
No Bt and 30%	1.000	1.014	1.029	1.044	1.051	1.062	1.055	1.055	1.055	1.041
Bt and 20%	1.000	1.011	1.017	1.030	1.038	1.047	1.043	1.044	1.043	1.030
Bt and 30%	1.000	1.016	1.030	1.047	1.055	1.066	1.060	1.060	1.060	1.044
					Yield (Kg per Hectare)					
Baseline	1.05	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.07
Bt and no WTO	1.05	1.05	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.08
No Bt and 20%	1.05	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.07
No Bt and 30%	1.05	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.07
Bt and 20%	1.05	1.05	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.08
Bt and 30%	1.05	1.05	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.08
					(Scenario Over Baseline)					
Bt and no WTO	1.000	1.001	1.002	1.003	1.005	1.006	1.006	1.006	1.006	1.004
No Bt and 20%	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999	0.999	1.000
No Bt and 30%	1.000	1.000	1.000	0.999	0.999	0.999	0.999	0.999	0.999	0.999
Bt and 20%	1.000	1.001	1.002	1.003	1.004	1.005	1.005	1.005	1.005	1.003
Bt and 30%	1.000	1.001	1.002	1.003	1.004	1.005	1.005	1.005	1.005	1.003

TABLE 3. Continued

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
					Production (1,000 Metric Tons)					
Baseline	4338	4407	4479	4548	4614	4679	4743	4808	4873	4610
Bt and no WTO	4338	4419	4501	4583	4662	4739	4805	4872	4940	4651
No Bt and 20%	4338	4448	4540	4671	4771	4875	4921	4991	5055	4735
No Bt and 30%	4338	4470	4605	4746	4848	4963	5001	5069	5137	4798
Bt and 20%	4338	4461	4562	4699	4812	4926	4973	5044	5110	4769
Bt and 30%	4338	4481	4623	4776	4889	5015	5055	5124	5194	4833
					(Scenario Over Baseline)					
Bt and no WTO	1.00	1.003	1.005	1.008	1.010	1.013	1.013	1.013	1.014	1.009
No Bt and 20%	1.00	1.009	1.014	1.027	1.034	1.042	1.038	1.038	1.037	1.027
No Bt and 30%	1.00	1.014	1.028	1.044	1.051	1.061	1.054	1.054	1.054	1.040
Bt and 20%	1.00	1.012	1.019	1.033	1.043	1.053	1.048	1.049	1.049	1.034
Bt and 30%	1.00	1.017	1.032	1.050	1.059	1.072	1.066	1.066	1.066	1.047

Consequently, China's cotton production increases in all scenarios, ranging from 3.4 to 4.7 percent on average, induced from Bt adoption and China's accession to the WTO. A major increase in cotton production occurrs in Hebei (5.3 to 6.8 percent), Hunan (4.2 to 5.3 percent), and Hubei (3.9 to 5.3 percent) provinces, as indicated in Table 4. These regions have a high potential for Bt adoption and area expansion.

Driven by the expansion of the Chinese textile industry, China's cotton consumption, reported in Table 5, increases substantially. The average increase is 11 and 16 percent, respectively, for the two scenarios with the accession of China to the WTO.

As expected, higher domestic cotton production from Bt adoption results in a big decrease—5.4 percent—in China's cotton net imports (Table 5). China's WTO accession causes the country's cotton net imports to increase substantially: between 455 and 676 tmt annually, an average increase of between 69.3 and 102.8 percent. The impact of China's WTO accession on imports is significantly higher than that of Bt adoption. Consequently, the net impact of WTO accession and Bt adoption on cotton imports is positive and significant. Cotton imports would be expected to exceed the TRQ in 2004 or 2005 under the last four scenarios.

Total world cotton imports decrease by an average of 0.4 percent for the case of the Bt adoption scenario, but world imports increase 3.9 to 5.8 percent for the WTO accession scenarios, as shown in Table 6. The United States gains in all scenarios except with Bt cotton adoption only (scenario 1), in which case U.S. cotton exports decrease by 0.5 percent. The United States benefits significantly from China's WTO accession, with an average increase in cotton exports of between 73 tmt and 109 tmt compared to the baseline.

Conclusions

Cotton policy in China has evolved from a centrally planned process to a more market-oriented approach. Domestic marketing policy was reformed from one of strict government control, implemented in the first five-year planning period through 1984, to a negotiated contract market in the 1985–99 period. In recent years, it has moved even closer to a free market system.

Compared to domestic cotton policies, however, reforms in China's cotton trade have been quite slow. Cotton trade was strictly controlled by the Chinese government through its state trading company until the years just before China's accession to the

WTO. Trade policy reform in China has a major impact on world cotton markets. China's accession to the WTO in December of 2001 has been the latest step in the country's incremental journey from an economy characterized by planning and self-sufficiency to one driven by market and global integration.

China's cotton sector is modeled here in a comprehensive supply and demand framework. Major components of the cotton model include supply and demand sectors, price linkages, and textile output. Cotton production is projected for each of nine cotton production regions. Area sown to cotton is modeled in a two-stage framework. The first stage determines the gross cropping area. The second stage uses economic variables to allocate the total area for cotton and major substitute crops. Cotton demand is calculated separately for yarn use and non-yarn use. Total fiber demand and cotton share are estimated for each end use.

The developed cotton sector model was then linked to the FAPRI modeling system to measure the impact of China's WTO accession and the adoption of Bt cotton on the Chinese and U.S. cotton sectors. China has become the second-largest Bt cotton producer in the world, just behind the United States. Bt adoption could significantly reduce China's cost of cotton production.

The results of China's accession without Bt cotton adoption indicate that imports and domestic production of cotton in China and U.S. cotton exports increase with WTO accession. The results of Bt cotton adoption without WTO accession suggest a significant increase in domestic cotton production and a decrease in imports and exports of U.S. cotton. The results are dominated by the WTO accession under the scenarios of both WTO accession and Bt cotton adoption assumption.

Our results suggest that Chinese cotton producers benefit from both Bt adoption and WTO accession. Producers in the United States lose slightly from China's Bt adoption but gain significantly from China's WTO accession. The United States enjoys a significant net benefit from both WTO accession and Bt adoption, as the impact of China's WTO accession is significantly higher than that of China's Bt adoption.

TABLE 4. Impact on Chinese regional production

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
Production under Scenario with Bt and 30% increase in Yarn Output (1,000 Hectares)										
Xinjing	1468	1498	1533	1573	1596	1622	1624	1636	1649	1578
Henan	735	753	775	801	820	842	850	862	876	813
Shandong	571	588	608	631	648	667	674	685	696	641
Hubei	332	340	350	363	373	383	387	393	400	369
Jiangsu	356	363	374	386	396	406	409	416	422	392
Anhui	263	275	288	304	316	330	338	348	359	313
Hebei	262	275	290	307	322	338	346	357	369	319
Hunan	171	174	179	185	190	195	197	200	203	188
Other	286	294	304	316	325	336	340	346	353	322
(Scenario over Baseline)										
Xinjing	1.000	1.015	1.027	1.043	1.050	1.060	1.053	1.054	1.054	1.039
Henan	1.000	1.015	1.029	1.044	1.054	1.065	1.060	1.060	1.060	1.043
Shandong	1.000	1.017	1.033	1.052	1.061	1.074	1.068	1.068	1.068	1.049
Hubei	1.000	1.019	1.036	1.055	1.066	1.080	1.074	1.074	1.073	1.053
Jiangsu	1.000	1.015	1.030	1.046	1.056	1.067	1.062	1.062	1.061	1.044
Anhui	1.000	1.016	1.031	1.048	1.055	1.065	1.058	1.057	1.057	1.043
Hebei	1.000	1.025	1.047	1.071	1.085	1.102	1.095	1.094	1.094	1.068
Hunan	1.000	1.018	1.035	1.054	1.066	1.080	1.075	1.075	1.075	1.053
Other	1.000	1.020	1.039	1.059	1.072	1.087	1.082	1.082	1.082	1.058
Production under Scenario with Bt and 20% increase in Yarn Output (1,000 Hectares)										
Xinjing	1468	1491	1512	1547	1570	1593	1596	1610	1621	1556
Henan	735	750	767	790	810	830	839	852	864	804
Shandong	571	586	600	621	638	655	663	674	685	632
Hubei	332	338	346	357	367	376	380	387	394	364
Jiangsu	356	362	369	380	390	399	403	410	416	387
Anhui	263	274	284	298	311	323	331	342	352	309
Hebei	262	274	286	302	316	331	340	351	363	314
Hunan	171	174	177	183	188	192	194	197	200	186
Other	286	292	300	311	321	330	335	341	348	318

TABLE 4. Continued

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
					(Scenario Over Baseline)					
Xinjing	1.000	1.010	1.014	1.026	1.033	1.040	1.036	1.036	1.036	1.026
Henan	1.000	1.011	1.018	1.031	1.040	1.050	1.046	1.047	1.046	1.032
Shandong	1.000	1.013	1.020	1.034	1.044	1.055	1.050	1.051	1.050	1.035
Hubei	1.000	1.014	1.022	1.038	1.049	1.060	1.055	1.056	1.055	1.039
Jiangsu	1.000	1.011	1.018	1.031	1.041	1.050	1.046	1.047	1.046	1.032
Anhui	1.000	1.011	1.015	1.028	1.036	1.044	1.038	1.039	1.038	1.028
Hebei	1.000	1.019	1.031	1.052	1.066	1.081	1.076	1.076	1.075	1.053
Hunan	1.000	1.014	1.024	1.040	1.052	1.064	1.061	1.061	1.061	1.042
Other	1.000	1.016	1.026	1.044	1.057	1.070	1.066	1.067	1.066	1.046

TABLE 5. Impact on Chinese cotton consumption and trade

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
Consumption (1,000 Metric Tons)										
Baseline	5082	5132	5173	5216	5270	5312	5360	5391	5418	5261
Bt and no WTO	5081	5134	5176	5220	5274	5318	5364	5394	5422	5265
No Bt and 20%	5231	5444	5613	5804	6000	6060	6105	6139	6168	5841
No Bt and 30%	5306	5573	5819	6093	6365	6435	6482	6513	6543	6125
Bt and 20%	5231	5446	5620	5811	6010	6072	6116	6150	6179	5848
Bt and 30%	5306	5578	5824	6100	6373	6444	6491	6522	6552	6132
(Scenario Over Baseline)										
Bt and no WTO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No Bt and 20%	1.03	1.06	1.08	1.11	1.14	1.14	1.14	1.14	1.14	1.11
No Bt and 30%	1.04	1.09	1.12	1.17	1.21	1.21	1.21	1.21	1.21	1.16
Bt and 20%	1.03	1.06	1.09	1.11	1.14	1.14	1.14	1.14	1.14	1.11
Bt and 30%	1.04	1.09	1.13	1.17	1.21	1.21	1.21	1.21	1.21	1.16
Net Import (1,000 Metric Tons)										
Baseline	393	495	590	657	698	718	725	721	707	634
Bt and no WTO	393	485	571	626	655	664	668	661	644	596
No Bt and 20%	543	766	969	1122	1272	1271	1293	1287	1275	1089
No Bt and 30%	618	874	1110	1336	1560	1556	1589	1582	1568	1310
Bt and 20%	543	756	954	1101	1241	1231	1252	1244	1231	1061
Bt and 30%	618	867	1098	1313	1527	1514	1545	1536	1521	1282
TRQ	818.5	856.25	894	894	894	894	894	894	894	
(Scenario Over Baseline)										
Bt and no WTO	1.00	0.98	0.97	0.95	0.94	0.92	0.92	0.92	0.91	0.946
No Bt and 20%	1.38	1.55	1.64	1.71	1.82	1.77	1.78	1.78	1.80	1.693
No Bt and 30%	1.57	1.76	1.88	2.03	2.23	2.17	2.19	2.19	2.22	2.028
Bt and 20%	1.38	1.53	1.62	1.68	1.78	1.71	1.73	1.72	1.74	1.653
Bt and 30%	1.57	1.75	1.86	2.00	2.19	2.11	2.13	2.13	2.15	1.987

TABLE 6. Impact on U.S. and world cotton trade

	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
World Cotton Trade (1,000 Metric Tons)										
Baseline	4241	4295	4347	4392	4425	4452	4476	4495	4510	4404
Bt and no WTO	4241	4290	4338	4377	4405	4428	4452	4470	4485	4387
No Bt and 20%	4311	4414	4505	4579	4651	4658	4681	4695	4708	4578
No Bt and 30%	4344	4459	4563	4665	4763	4765	4790	4790	4797	4660
Bt and 20%	4309	4408	4498	4570	4638	4641	4666	4678	4692	4567
Bt and 30%	4344	4456	4558	4656	4751	4748	4773	4771	4779	4648
(Scenario Over Baseline)										
Bt and no WTO	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.996
No Bt and 20%	1.02	1.03	1.04	1.04	1.05	1.05	1.05	1.04	1.04	1.039
No Bt and 30%	1.02	1.04	1.05	1.06	1.08	1.07	1.07	1.07	1.06	1.058
Bt and 20%	1.02	1.03	1.03	1.04	1.05	1.04	1.04	1.04	1.04	1.037
Bt and 30%	1.02	1.04	1.05	1.06	1.07	1.07	1.07	1.06	1.06	1.055
U.S. Cotton Export (1,000 Metric Tons)										
Baseline	1880	1901	1934	1970	2005	2038	2071	2102	2130	2003
Bt and no WTO	1880	1897	1928	1960	1993	2024	2058	2089	2117	1994
No Bt and 20%	1923	1969	2013	2056	2106	2119	2148	2176	2204	2079
No Bt and 30%	1943	1993	2041	2098	2156	2163	2189	2202	2226	2112
Bt and 20%	1921	1965	2008	2052	2100	2111	2141	2169	2198	2074
Bt and 30%	1943	1991	2039	2093	2152	2154	2183	2193	2217	2107
(Scenario Over Baseline)										
Bt and no WTO	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.995
No Bt and 20%	1.02	1.04	1.04	1.04	1.05	1.04	1.04	1.04	1.03	1.038
No Bt and 30%	1.03	1.05	1.06	1.06	1.08	1.06	1.06	1.05	1.04	1.054
Bt and 20%	1.02	1.03	1.04	1.04	1.05	1.04	1.03	1.03	1.03	1.035
Bt and 30%	1.03	1.05	1.05	1.06	1.07	1.06	1.05	1.04	1.04	1.052

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