OVERSEAS ADOPTION OF BT COTTON: IMPLICATIONS FOR U.S. PRODUCERS

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Abstract

The U.S. share of world Bt cotton acreage has fallen from virtually 100 percent in 1996 to 75 percent in 2000. Three scenarios were examined simulating low, moderate and high impacts of foreign Bt cotton adoption in 1999. Increased production lead to a decrease in the world price of cotton ranging from 0.8 to 2.5 cents. Rising commodity program payments mitigated nearly all of the negative impacts of falling prices on U.S. producers. For U.S. cotton producers, the net economic benefits of Bt technology (benefits of domestic adoption minus the losses from overseas adoption) remain large. This may change, however, if the Adjusted World Price rises above the loan rate and if foreign adoption continues to grow relative to U.S. adoption.

Introduction

A number of studies have estimated the overall impact of Bt cotton technology on U.S. producers. These studies, covering the period 1996-98 find sizeable benefits to U.S. producers (Table 1). The lower figures reported in the Frisvold et al. (2000a) study are based on model assumptions leading to a greater drop in output prices. While the fall in output prices significantly affected producers in 1996 and 1997, activation of loan deficiency and market gain payments in 1998 largely mitigated the impact of falling market prices in that year. Gains to U.S. producers from U.S. Bt cotton adoption in 1999 and 2000 should be even higher than the numbers suggested in Table 1, given the rise in U.S. adoption rates and continuation of price support payments in those years.

From 1996-97, foreign adopters accounted for little of global Bt cotton acreage (Table 2). This soon changed as foreign acreage planted to Bt cotton varieties rose to 0.2 million hectares in 1998, to 0.5 million hectares in in 1999 and an estimated 0.7 million hectares in 2000. Some industry figures place foreign Bt cotton acreage even higher, with up to one million hectares planted in China alone (Vorman (1999), Pray et al. (2001). Precise figures for China are difficult to obtain, in part, because farmers save Bt cotton seed, selling it to other farmers or seed merchants. James (2000a, 2000b) reports estimates of Chinese Bt cotton acreage of 0.3 million hectares for 1999 and 0.5 million hectares for 2000. For 1999, Pray et al. (2001) estimated acreage at 0.38 hectares in 1999. Even taking more conservative estimates, foreign Bt cotton acreage in 2000 is as great as U.S. Bt cotton adoption in 1996.

While domestic adoption has been of significant benefit to U.S. producers via higher yields and lower pest control costs, increased foreign adoption will exert downward pressure on market prices for cotton. This study reports estimates of the impacts of foreign Bt cotton adoption on the world and U.S. farm price of cotton, based on simulations from a quadratic programming model calibrated to 1999 adoption and other economic data. We conclude by discussing near- and longer-term implications for U.S. producers.

Methods

A quadratic programming model of the U.S. and world cotton market developed by Frisvold et al. (2000a, 2000b) was updated to 1999 data. The model includes 31 regions within the United States as well as a Rest of World (ROW) region to account for open economy impacts. As typical of programming models, U.S. cotton supply is a step function, with steps representing marginal costs for Bt cotton adopters and non-adopters in each region. The step supply function is combined with linear functions for U.S. cotton demand and Rest of World (ROW) supply and demand. These four functions determine the equilibrium world price of cotton, as well as ROW production, overall cotton demand, and demand for U.S. cotton exports. The average price received by U.S. farmers differs from the world price (Cotlook 'A' index price), reflecting transport costs, quality differences and government market interventions. Changes in the world price may not be transmitted exactly to changes in the U.S. price. Following Sullivan et al. (1998) we adopt a baseline transmission elasticity of one. U.S. producers receive price premiums or discounts, modeled as fixed differences from the U.S. farm price price. In the model as in reality, producers receive Loan Deficiency (POP) payments or market gain payments if the adjusted world price falls below the loan rate.

In the baseline model, U.S. acreage, yields, prices, program payment rates, exports and cost are calibrated to actual USDA data. ROW cotton production, consumption, demand for U.S. cotton exports and the world price of cotton are also set equal to USDA and cotton industry data. Implicitly, this data already accounts for the impacts of ROW Bt cotton adoption. To estimate the impact of ROW adoption of Bt cotton, a supply shift parameter, z, is introduced into the ROW supply function:

$$Q_{RS} = a_{RS}\,(1- z) + b_{RS}\,P_w$$

where Q_{RS} is the quantity supplied by ROW, P_w is the world price and a_{RS} and b_{RS} are constants. To estimate the impact of Bt cotton adoption, we ask the counterfactual question, "what would the ROW supply function look like if Bt cotton had not been adopted?" If Bt cotton were not adopted in ROW, the ROW supply function would shift upward in a parallel fashion. Yield increases, cost reductions, or both from Bt cotton adoption are reflected in the size of z, which is set = 0 in the model baseline. Through the market equilibrium equation, this shift induces a shift in the equilibrium world price of cotton. One can then simulate how much higher the world price would have been had there been no ROW Bt cotton adoption.

Data

U.S. regional and aggregate data sources used in the model are discussed in Frisvold et al. (2000a; 2000b). Estimates of domestic and export demand elasticities were based on Duffy et al. (1990), Duffy and Wohlgenant (1991), and Sullivan (1989). ROW consumption, production, and demand for U.S. exports were derived from the Production Estimates & Crop Assessment Division of USDA's Foreign Agricultural Service and from various issues of the USDA Economic Research Service *Cotton and Wool: Situation and Outlook Yearbook*.

Table 2 shows acreage planted to Bt cotton by region. Figures include acreage planted to both Bt-only varieties and "stacked" Bt and herbicide resistant varieties. Data comes from James (1997, 1998, 1999, 2000a, 2000b), Pray (2001), Williams (1996, 1997, 1998, 1999) and USDA-NASS (2000). The United States still accounts for the bulk of world Bt cotton acreage at 75 percent in 2000. China is second, accounting for 18 percent of acreage in 2000. Countries in the "Other" category are Australia, Mexico, South Africa, and Argentina.

To construct estimates of the z-shift parameter, we rely on information and data provided in Bean (1999), Monsanto (1999), and Pray et al. (2001) for China. In 1999, Bt cotton was also grown in Australia, Mexico, South Africa, and Argentina with the bulk in Australia. Combined, these countries accounted for less than 5 percent of global Bt cotton acreage. Studies of Bt cotton adoption impacts in Australia by CRDC (1998) and by Hancock et al. (1999) found very small yield benefits (less than a 1-percent

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:184-186 (2001)
National Cotton Council, Memphis TN

yield gain) and, on average, no net cost reduction once technology fees were paid. For these reasons, we focused our analysis on China.

Pray et al. (2001) conducted a survey of 283 cotton farmers in Hebei and Shandong Provinces in 1999, estimating impacts of Bt cotton adoption. These provinces account for most of China's Bt cotton acreage. In 1999 Bt cotton accounted for about 10 percent of China's cotton acreage. However, reported crop yields in Hebei and Shandong Provinces were much higher than reported national average yields, on the order of 3-3.5 times higher. So, Bt cotton accounts for a much higher share of China's cotton production than the 10-percent adoption rate would suggest. According to Monsanto (1999), lint yields rose by 4 to 12 percent in Hebei Province in 1998. Pray et al. did not find evidence of yield increases in 1999, but did estimate significant costs savings, with costs per pound falling 20 to 33 percent.

Based on information from Monsanto (1999) and Pray et al. (2001) we constructed low, moderate and high impact scenarios assuming that Bt adoption increased production in China (at constant prices) 1.3 percent, 2.7 percent and 4 percent. Increased productivity in China leads to a smaller percentage shift in the ROW supply function. The ROW supply shift is such that, holding the world price fixed at 1999 levels, Bt adoption increases ROW supply 0.33 percent in the low impact scenario, 0.66 percent in the moderate case, and 1 percent in the high impact case.

Results

Table 3 shows simulated impacts of foreign Bt adoption on the world and U.S. farm price for cotton. The world price falls as a result of adoption by 0.8 cents in the low impact case, 1.7 cents in the moderate case, and 2.5 cents in the high impact case. The U.S. farm price falls slightly less, by 0.7 cents in the low impact case, 1.4 cents in the moderate case, and by 2.2 in the high impact case. The falling price is a benefit to purchasers of cotton. For producers, cash marketings decline. In the United States, loan deficiency and market gain payments increase to compensate for the fall in market price. The net effect (combining market price and commodity program payment effects) of foreign Bt adoption on U.S. producer returns was negligible. Federal budget outlays for the cotton program increase, however.

Discussion

U.S. producer losses from overseas Bt cotton adoption come from downward pressure on world and U.S. farm prices for cotton. For U.S. cotton producers, the net economic benefits of Bt technology (benefits of domestic adoption minus the losses from overseas adoption) remain large. This may change, however, if the Adjusted World Price rises above the loan rate and if foreign adoption continues to grow relative to U.S. adoption. Ironically, in a higher price environment, price support programs may become inactive and cease to provide producers with a cushion against impacts of foreign Bt cotton adoption.

On a more positive note for U.S. producers, the growing worldwide adoption of Bt cotton and other transgenic crops signals greater international acceptance of biotechnology. James (2000b) reports that 13 countries grew transgenic crops in 2000. Under WTO rules, countries planting and consuming transgenic crops themselves have less scope for imposing import restrictions on U.S. transgenic crops.

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Table 1. Estimates of impacts of Bt cotton adoption on U.S producers.

Study	Year Covered	Producer Benefits $ Millions
Giannessi and Carpenter	1998	$92.7
Falck-Zepeda et al. (2000a)	1996	$140.8
Falck-Zepeda et al. (2000b)	1997	$80.0
Frisvold et al. (2000a)	1996-98	$35.6 (3-year avg.)
Frisvold et al. (2000a)	1998	$88.4

Table 2. International acreage planted to Bt cotton.

Country	1996	1997	1998	1999	2000
			(million hectares)		
USA	0.7	0.9	1.1	1.7	2.1
China	0.0	0.0	0.1	0.4	0.5
Other	0.0	0.1	0.1	0.1	0.2
Total	0.7	1.0	1.3	2.2	2.8
US Share	100%	91%	86%	78%	75%

Includes varieties with stacked Bt and herbicide resistant genes.

Table 3. Impact of foreign Bt cotton adoption on world price of cotton: simulation based on 1999 data.

	Low Impact	Moderate Impact	High Impact
Supply shift as a percent of baseline ROW production	0.33%	0.66%	1%
Change in world price (cents / lb.)	-0.8	-1.7	-2.5
Change in U.S. price (cents / lb.)	-0.7	-1.4	-2.2