USDA
United States Department of Agriculture

Economic Research Service

ERS Research Briefs

Size and Distribution of Market Benefits From Adopting Biotech Crops

Gregory K. Price, William Lin, José B. Falck-Zepeda, and Jorge Fernandez-Cornejo

TB-1906 November 2003

Producers, Consumers, and Technology Innovators Share Benefits

The adoption of biotech crops, particularly herbicide-tolerant soybeans and cotton, has been rapid since their commercial introduction in 1996. Biotech crops can offer producers distinct advantages over conventional varieties, such as potentially higher yields and lower pest control costs. But producers are not the only ones to benefit. Biotechnology developers and seed companies charge technology fees and seed premiums to adopters who plant biotech varieties. In addition, U.S. and foreign consumers enjoy lower commodity prices that result from biotechnology-induced increases in food supplies, though biotech-wary consumers may feel excluded from these gains.

What Is the Issue?

Much debate has centered on how benefits from agricultural biotechnology are shared among stakeholders. Different studies estimate significantly different portions of the total biotech benefit "pie" shared by U.S. farmers, biotechnology innovators (those who develop, manufacture, and sell biotech crop seed), U.S. consumers, and producers and consumers in other countries. But to what extent do these estimates vary as a direct result of methodological approaches, assumptions regarding the responsiveness of production and consumption to changes in commodity prices, which crops are analyzed, study period, and the choice of data source on farm-level consequences of biotech crops' adoption?

How Was the Study Conducted?

This study seeks to determine the sensitivity to changes in various research assumptions and data sources of the estimated size and distribution of benefits from adopting *Bacillus thuringiensis* (Bt) cotton, herbicide-tolerant cotton, and herbicide-tolerant soybeans in 1997. The stakeholders considered are U.S. farmers, U.S. consumers, biotechnology developers, germplasm suppliers, and foreign producers/consumers. We focus on specific and readily quantifiable market benefits accruing to these stakeholders.

We use a model in which the benefits from the sale and adoption of each biotech crop's seed are measured as changes to economic welfare in both the seed input and commodity output markets. The framework accounts for monopoly profits, resulting from intellectual property rights protection, that accrue to the innovators in the input market. The model also measures economic welfare changes (from higher production efficiency and lower commodity prices) for producers and consumers in a competitive commodity market.

The change in economic welfare from each biotech crop stems from an increase in commodity supply, which is the result of biotech-induced yield increases and savings in pest control costs. Our estimates of market benefits from agricultural biotechnology are based on data sources that isolate these farm-level effects. The change in supply is integrated into the rest of the model to calculate pre- and post-biotech prices and quantities in an international setting. While our analyses use 1997 data, the analytical framework is, by and large, applicable to today's market conditions.

What Did the Study Find?

Both total benefits and their distribution among stakeholders are sensitive to analytical assumptions. Estimated market benefits of agricultural biotechnology—in a base scenario using representative data and reasonable assumptions about market responsiveness—ranged from $213 million to $308 million for each of the three biotech crops in 1997. Gains ranging from $212.5 million to 300.7 million (depending on the data source) were associated with the planting of **Bt cotton**. **Herbicide-tolerant cotton** improved total welfare by an estimated $231.8 million, while the adoption of **herbicide-tolerant soybeans** yielded $307.5 million in benefits. The estimated benefits reported in this study represent 2-5 percent of the respective U.S. crop values in 1997.

In our base case, U.S. farmers received about a third of the total benefit from adopting Bt cotton (previous studies estimated the share at around 50 percent), and just 20 percent of the estimated total benefit from adopting herbicide-tolerant soybeans—at the lower end of the benefit range in previous studies. With herbicide-tolerant cotton, a small U.S. farmers' share (4 percent) can be attributed to the premia paid for biotech seed (versus conventional seed) and low cotton prices in 1997, which offset the benefit of higher yields. Biotechnology innovators captured about 30 percent and 68 percent of the estimated total benefits from the adoption of Bt cotton and herbicide-tolerant soybeans. For herbicide-tolerant cotton, we estimate that U.S. consumers and foreign producers and consumers received the bulk of the estimated benefits.

By using the same model to re-estimate the benefits under different assumptions about market responsiveness, the results demonstrate their sensitivity to what an analyst accepts as reasonable expectations of how changes in supply affect U.S. and world prices. Supply responsiveness affects the estimated benefits overall, and affects the benefits to U.S. farmers more than the benefits to U.S. consumers. For example, doubling the supply sensitivity reduces the estimated total benefit by about half in the case of herbicide-tolerant soybeans and causes U.S. soybean producers' share of the estimated total benefit to disappear.

Year-specific variables, such as pest infestation levels and weather, also affect the size and distribution of benefits. This suggests that multiyear analyses will yield more reliable estimates of the market benefits from biotech crops than single-year estimates.

Although not included in this study's benefit estimates, important market benefits—such as the ease of pest management associated with herbicide-tolerant crops and the insurance value of insect-resistant crops—can affect the results. In addition, potential nonmarket benefits, including effects on the environment and human health, could influence the benefit estimates. Other environmental effects of biotechnology—such as pesticide toxicity levels, length of persistence in the environment, and impacts on nontarget species— would influence total net benefits of biotech crops, but also are not part of our assessment.