# Conclusions

The estimated total benefit arising from the adoption of three biotech crops in 1997 varied significantly across crops, ranging from $213 million to $301 million for Bt cotton (depending on the data source) to $308 million for herbicide-tolerant soybeans. The adoption of herbicide-tolerant cotton resulted in an estimated total gain of $232 million. This study's estimate of the total benefit from adopting Bt cotton exceeds those of other studies that consider the 1997 crop. In contrast, the estimate of the total benefit for herbicide-tolerant soybeans lies toward the lower end of the range reported in previous analyses.

While a number of previous studies have estimated that U.S. producers obtain about half of the estimated total benefits, this analysis finds that they received about a third or less in 1997. Past estimates of U.S. producers' benefit shares vary widely in the case of herbicide-tolerant soybeans, ranging from 20 percent to 77 percent. In this study, the share of the estimated benefits that accrued to domestic soybean producers is at the lower end of that range. U.S. producers received a small portion of the estimated benefits from herbicide-tolerant cotton; modest savings in pest control costs did not compensate for losses resulting from lower market prices.

This analysis finds that innovators received 30 percent (average of the results from the estimated ARMS effects and EMD) of the estimated total benefits arising from Bt cotton adoption, a value generally lower than in other studies. In contrast, innovators captured 68 percent of the estimated benefits from herbicide-tolerant soybeans, considerably higher than previous estimates. In the cases of these two biotech crops, U.S. consumers received a small share of the estimated total benefits (5 percent to 17 percent), a result comparable with other studies. With herbicide-tolerant cotton, 57 percent of the estimated benefits accrued to U.S. consumers because of lower commodity prices.

Considerable uncertainty surrounds the estimates of total benefits arising from the adoption of biotechnology. Of the three crops, Bt cotton has the widest dispersion of estimated total benefits, ranging from -$9 million to $431 million with the estimated ARMS effects, compared with the mean of $213 million. The dispersion of estimated total benefits appears to be smaller for both herbicide-tolerant cotton and soybeans.

Estimated total benefits—as well as the shares that accrue to the various stakeholders—are sensitive to the choice of analytical framework, particularly with respect to the nature of the U.S. and ROW supply curves (linear versus nonlinear) and the shift in supply (parallel versus nonparallel). Results also depend on assumptions concerning the U.S. and ROW supply and demand elasticities. The sensitivity analysis shows that altering the U.S. and ROW supply elasticities has a bigger impact on the estimated stakeholder benefits than changing the demand elasticities.

Many other factors, which are not quantified in this study, influence the size and distribution of benefits stemming from biotech adoption. Stakeholder benefits depend on the extent to which both market and nonmarket benefits are included in the analysis. This study captures only certain market benefits, disregarding the convenience value of simplicity and flexibility in weed control programs and the insurance value of crop protection associated with insect-resistant crops. Given the minimal farm-level effects associated with herbicide-tolerant soybeans, ease of pest management is regarded as the primary reason behind the rapid adoption of this technology by U.S. farmers.

Neither does this study fully consider nonmarket benefits, such as impacts on the environment and human health, which may be significant. Biotechnology led to reductions in pesticide use (measured in pounds of active ingredients) for Bt cotton in the Southern Seaboard, herbicide-tolerant cotton nationwide, and herbicide-tolerant soybeans in some major production regions. However, analyzing changes in pesticide use alone does not accurately measure the total direct benefits to the environment and human health.

First generation biotech crops have had input trait characteristics, such as insect resistance, that primarily benefit producers. As biotech crops with output traits are developed, they could directly benefit consumers. In addition, the benefits arising from the adoption of biotech crops depend on who develops the technologies. If biotech crops were to be developed by the public sector, the technologies would likely be public goods. As a result, consumers may capture a greater proportion of the benefits.

Last, benefits from biotech crops are dependent on year-specific and crop-specific factors, such as weather and pest infestation levels. This suggests that multiyear analyses and analyses of other crops, such as corn, would yield a more accurate perspective on the size and distribution of benefits resulting from the adoption of agricultural biotechnology. This extended analysis will be particularly relevant with increased technology transfer to the ROW, the emergence of several competing biotechnology varieties for some crops, and evolving pest management requirements for Bt products that may affect pesticide use.