TWO APPROACHES TO MEASURING THE ECONOMIC IMPACT OF STARLINK CORN ON U.S. PRODUCERS

Troy G. Schmitz, Arizona State University
Andrew Schmitz, University of Florida
Charles B. Moss, University of Florida

Contact Information
Dr. Andrew Schmitz
Food and Resource Economics
University of Florida
Post Office Box 110240
Gainesville, FL 32611-0240
aschmitz@mail.ifas.ufl.edu

Selected Paper prepared for presentation at the American Agricultural Economics Association, Annual Meeting, Denver, Colorado, August 1-4, 2004

TWO APPROACHES TO MEASURING THE ECONOMIC IMPACT OF STARLINK CORN ON U.S. PRODUCERS

Troy G. Schmitz, Andrew Schmitz, and Charles B. Moss

ABSTRACT

The discovery of StarLink corn in U.S. food products caused considerable disruption in the corn markets in 2000 and 2001. We estimated two models on the impact of StarLink corn over the 2000/2001 marketing year. In the first model, to segregate the U.S. corn market, identity preservation costs (IP costs) were imposed on the U.S. grain handling system to deal with both domestic and export sales of food corn and export sales of non-food corn to Japan. In the second model, structural changes in corn demand were taken into account. Without taking into account Loan Deficiency Payment Program (LDP) payments, significant costs were incurred by producers as a result of StarLink. However, the effectively reduced the loss in revenue that would have been caused by StarLink, since there were periods of time immediately following the discovery of StarLink during which the market price dropped below the loan rate for corn. It was estimated that StarLink caused U.S. producers to lose between $25 and $290 million in revenue.

TWO APPROACHES TO MEASURING THE ECONOMIC IMPACT OF STARLINK CORN ON U.S. PRODUCERS

Introduction

In the late 1990s, Aventis CropScience (Aventis), a multinational firm based in France, introduced StarLink corn into the United States with the knowledge that the U.S. Environmental Protection Agency had not approved StarLink corn for human consumption. StarLink corn contains Cry9C protein, which is toxic to European corn borers and certain other insect pests. On September 18, 2000, the Cry9C gene contained in StarLink corn was found in a sample of Taco Bell taco shells (Kraft Foods, Inc.). After testing by the U.S. Food and Drug Administration, nearly 300 food products were recalled. Because of the recalls, Archer Daniels Midland began testing corn deliveries at its elevators on October 12, 2000, and Japan temporarily halted U.S. corn imports on October 27 until testing procedures were firmly established.

StarLink corn was grown on approximately 362,000 acres in 2000, roughly 40% of which was in Iowa. It became commingled with non-StarLink corn in the U.S. grain handling system. According to Lin et al. (2001), commingling of StarLink corn with other corn varieties was exacerbated by three factors: (1) some of the corn grown on the buffer zone was probably cross-pollinated with StarLink corn, (2) a portion of the StarLink corn (including that grown on the buffer zone) had entered the marketplace prior to the effort to contain StarLink-commingled corn, and (3) some elevators did not know they were receiving StarLink-commingled corn. The commingled corn may have come from either the 1999 or 2000 corn crop because StarLink was grown in 1999 but was not detected. For U.S. corn to be sold for food purposes both in the United States and in major importing countries, such as Japan and South Korea, it now had to be segregated and tested and certified StarLink-free. Once implemented, StarLink testing became highly stringent—the tolerance level ranged from one kernel in a sample of 400 (in the United States) to as much as one kernel in three samples of 800 (in Japan).

As a direct result, several class-action lawsuits ensued. Fingers et al. v. Kraft Foods North America, Inc, et al. was one such case. The plaintiffs claimed they had allergic reactions to food containing Cry9C. The Centers for Disease Control tested the 17 people, who claimed StarLink had made them sick, and found that none of them had antibodies consistent with allergic reactions to StarLink. However, despite these results, a federal judge approved a $9 million settlement in March 2002 (Robinson 2002).

Mulholland et al. v. Aventis Crop Science USA Holding, Inc. was another such case. The plaintiffs, who were non-StarLink corn growers in seven Mid-western states, claimed property damage and corn loss claims. Property damage claimants were compensated for lost market value, transportation, and storage costs resulting from actual contamination of their crops, fields, equipment and property. Corn loss claimants were compensated for the alleged reduction in the general price of corn due to the presence of StarLink corn in the U.S. corn supply. A settlement for $110 million was reached in February 2003 (Uchtmann 2002).

The latter case is also applicable to ongoing debates over the acceptance and impacts of genetically modified organisms (GMOs) both within the United States and abroad. The StarLink incident illustrates the complexity of isolating crop varieties within the existing grain marketing system and preventing unwanted commingling.

The discovery of StarLink in food products caused considerable disruption in corn markets in 2000 and 2001 (Lin et al. 2001-2002). To segregate the U.S. corn market, identity preservation costs (IP costs) were imposed on the U.S. grain handling system to deal with both domestic and export sales of food corn and export sales of non-food corn to Japan. These costs reduced the revenue that U.S. corn producers would have received in the absence of StarLink during the 2000/2001 marketing year. However, the Loan Deficiency Payment Program (LDP) effectively reduced the loss in revenue due to StarLink, since there were periods of time immediately following the discovery of StarLink during which the market price dropped below the loan rate for corn. This study develops one model that encompasses both IP costs and the LDP program to obtain empirical estimates of the impact of StarLink on U.S. corn producers over the 2000/2001 marketing year. These quantitative results are consistent with the results of Lin et al. (2001). A second model is developed that incorporates the structural changes in corn demand. The dollar impacts from both models as a result of StarLink are compared to the court settlement amount referred to earlier.

Theoretical Framework (No Structural Change in Demand)

Domestic and foreign corn markets facing the United States are depicted in Figure 1 (Moschini, Lapan, and Sobolevsky 2000; Gardner 2000; Schmitz, Schmitz, and Dumas 1997; and Just, Hueth, and Schmitz 1982). Panel A represents the U.S. corn market and Panel B represents the export market for U.S. corn in the rest of the world. The total supply curve for U.S. corn is S_T. This supply curve is vertical because the forthcoming analysis focuses on the implications of StarLink for the 2000/2001 marketing year only. Shipments of corn containing StarLink did not get turned away until October 15, 2000, at which time nearly the entire U.S. corn crop had been harvested. Producers did not have time to adjust their planting decisions; hence the supply of both food and non-food corn for the 2000/2001 marketing year was already fixed by the time StarLink was discovered.

The total domestic demand schedule for U.S. corn in the absence of StarLink is D_T in Panel A. The excess supply and excess demand schedules for all U.S. corn are ES_{US} and ED_{US} (Panel B), respectively. The equilibrium price for U.S. corn in the absence of StarLink is P*. The total quantity of corn produced and consumed in the U.S. is Q* and Q_D^*, respectively.

Total U.S. corn demand is divided into the demand for food corn (D_F) and the demand for non-food corn (D_N). The equilibrium quantity of food corn consumed in the U.S. in the absence of StarLink is Q_F^* and the quantity of non-food corn consumed is Q_N^*. The total equilibrium quantity of corn exported by the U.S. is X^*, which is comprised of U.S. food corn exports (X_F^*) and U.S. non-food corn exports (X_N^*).

The discovery of StarLink in the U.S. grain handling system introduced additional IP costs in the U.S. corn sector. Elevators were willing to pay less for corn because the additional IP costs had to be borne directly throughout the supply chain for all food corn sold to both domestic and foreign markets and to all non-food corn exports to Japan.

The IP costs induced by StarLink caused the domestic demand for food to shift to D_F^S (Figure 1). This resulted in a new (kinked) demand curve for all U.S. corn equal to D_T^S, which shifted the import demand schedule for U.S. food corn from ED_F to ED_F^S. In addition, the import demand schedule for Japanese non-food corn imports (not shown but included in the total import demand for U.S non-food corn) also shifted inward. This caused a slight reduction in the import demand schedule for all U.S. non-food corn exports from ED_N to ED_N^S. These two reductions in the demand for U.S. food and non-food exports resulted in a new (kinked) excess demand schedule for all U.S. corn equal to ED_{US}^S.

The equilibrium price of corn induced by StarLink dropped to P^S, while Q^* did not change, because U.S. producers did not have time to adjust supply during the 2000/2001 marketing year. However, the total quantity of corn consumed in the United States increased from Q_D^* to Q_D^S. The quantity of food corn consumed in the United States was reduced from Q_F^* to Q_F^S and the quantity of non-food corn consumed in the United States increased from Q_N^* to Q_N^S.

Total U.S. corn exports were reduced from X^* to X^S as a result of StarLink. U.S. food corn exports dropped from X_F^* to X_F^S and U.S. non-food corn exports changed from $X_N^*$to X_N^S. The relative shapes of the supply and demand curves drawn in Figure 1 depict the situation in which U.S. exports of non-food corn increased from X_N to X_N^S because of StarLink. However, depending upon the relative shapes of the demand schedules, U.S. exports of non-food corn could theoretically be higher or lower after StarLink was introduced. There is a trade-off between the outward shift in the excess supply schedule, that induces an increase in U.S. non-food corn exports, and the inward shift of the excess demand schedule for non-food corn, which induces a decrease in U.S. non-food corn exports.

The economic impact of StarLink on U.S. corn producers is measured by the difference between the total revenue in the absence of StarLink and the total revenue in the presence of StarLink. Using this measure of economic loss, if it had not been for StarLink, U.S. corn producers would have received an additional amount of revenue equal to the cross-hatched area in Panel A of Figure 1 over the 2000/2001 marketing year, *ceteris paribus.*

The Costs of Identity Preservation

The discovery of StarLink in the grain handling system, in October 2000, forced grain handlers who wanted to sell their corn into the food corn market or to the Japanese feed market to separate corn along the supply chain. The combination of all costs incurred due to testing and segregating corn throughout the entire supply chain is referred to as IP costs. When grain is delivered to an elevator, it is dumped into a pit and then transferred via a lift to a chain that distributes the grain to various storage bins in the elevator. To keep corn separate, farmers must be responsible for keeping the grain path between StarLink and StarLink-free deliveries clean, and separate facilities must be established and maintained. Establishing separate grain handling facilities introduces additional costs from inefficient utilization of space (sometimes referred to as "storing air").

We use estimates on segregation costs for corn based on studies, including Bender et al. (1999); Maltsbarger and Kalaitzandonakes (2000a); and Lin et al. (2000). Maltsbarger and Kalaitzandonakes (2000a,b) and Bender et al. (1999) estimated the cost of separating high oil corn. While there is value in separating high oil corn, the degree of separation required to obtain the premium allows for a much higher degree of tolerance than the tests developed for StarLink. Specifically, a variation in the relative corn content may result in some dockage but may not disqualify the entire shipment of corn, while one kernel in a sample of 400 kernels (or even three samples of 800 kernels in the case of Japan) can cause a shipment of corn to be rejected. Given this difference, we suggest that the separation cost for StarLink is somewhat higher than for high oil corn.

Given the range of incremental costs reported in the literature, there are several ways to define the increased cost of grain segregation. First, we could simply use the Lin et al. (2000) results of 22¢ per bushel. These results are closest to official USDA estimates. However, the estimates are somewhat higher than the others, because the segregation costs developed by Lin et al. (2000) include 4¢ per bushel for testing. Deducting the cost of testing from the USDA results yields an estimated IP cost of 18¢ per bushel, which appears to be more consistent with the other results for corn. For the purposes of obtaining empirical results in this study, we approximate the IP costs associated with StarLink by averaging the mid-point of the Maltsbarger and Kalaitzandonakes (2000b) results with the results for Lin et al. (2000) adjusted by the testing cost, the European Union estimate, and the estimate from Bender et al. (1999). This procedure gives an average IP cost of 19.75¢ per bushel, which we use in our analysis. However, we also perform a sensitivity analysis at a much lower IP cost estimate of 10¢ per bushel (Schmitz et al. 2003).[1]

The Impact of StarLink (IP Cost Model)

The Absence of the LDP Program

In our analysis, the 1997-1999 period was used because these are the most recent years in which we know (for certain) the marketing conditions that prevailed in the absence of StarLink. To estimate the impact of StarLink, it is necessary to differentiate between food and non-food corn. The USDA-ERS separates corn into feed and "Food, Seed, and Industrial Use" (FSI). The FSI category contains high fructose corn syrup (HFCS), dextrose, starch, fuel, beverages, products, and seed. The data on FSI reported for the USDA from 1980/81 through 1999/00 are provided in Table 1. StarLink corn is acceptable for use in creating ethanol fuel. In addition, some companies did not restrict the use of StarLink corn for HFCS (mostly used in making soft drinks), while other companies (such as Pepsi) did. Due to the lack of information regarding how much HFCS was processed from corn that contained StarLink, we assume that one-half of the HFCS was certified StarLink-free. Therefore, for the purposes of this study, food corn is defined as that contained in the FSI category, minus the amount used for fuel, minus one-half of the amount used for HFCS.

The amount of corn produced by the United States is given in Column 1 of Table 1. This supply is either sold as exports (Column 2), feed consumption in the United States (Column 3), or FSI consumption in the United States (Column 4). Total domestic use of U.S. corn (Column 5) is equal to the sum of feed and FSI from the prior two columns. In this study, food corn (Column 6) is subtracted from domestic use to compute the amount of non-food corn consumed in the United States (Column 7).

Average total U.S. corn production from 1997 to 1999 was 9.46 billion bushels, of which 1.8 billion bushels were sold as combined exports, 1.05 billion bushels were sold as U.S. food corn, and 6.6 billion bushels were sold as U.S. non-food corn. Hence, 13.7% of all corn consumed in the United States is considered food corn and the remaining 86.3% is considered non-food corn. It is assumed that U.S. food and non-food corn are exported at the same ratio as in the domestic U.S. market. Hence, 1,807 million bushels (Table 1, Column 2) of the total U.S. corn exports are divided into 248 million bushels of food corn exports and 1,559 million bushels of non-food corn exports.[2]

As discussed previously, the IP costs associated with StarLink result in the following: (1) a downward shift in the intercept of the demand schedule for U.S. food corn; (2) a downward shift in the intercept of the excess demand schedule for U.S. food corn exports; and (3) a slight downward shift in the intercept of the excess demand schedule for U.S. non-food corn that is caused by the fact that IP costs must also be incurred for non-food shipments to Japan. To obtain empirical estimates of the losses accruing to producers because of StarLink, we must first determine the degree to which the intercepts of these curves shifts. Each of these is discussed in turn.

The 3-year average price of corn received by U.S. producers, as reported by the National Agricultural Statistical Service (NASS) from September 1997 through August 2000, was 2.06¢ per bushel. Hence, additional IP costs of 19.75¢ per bushel represent a downward shift of 9.6% in the intercept of the demand schedule for U.S. food corn. This translates into an effective shift in the entire demand schedule for all U.S. corn by 1.3%, because food represents only 13.7% of the entire demand schedule for U.S. corn.

The excess demand for U.S. food corn exports must also shift downward by the same percentage as above (1.3%), because the additional IP costs must be incurred on all food corn exported from the United States and because it is assumed that the ratio of food to non-food corn exports is the same as the ratio of food to non-food corn consumed in the United States.

Total average exports of U.S. corn to Japan were 587 million bushels over the 1997/98 through 1999/2000 marketing year, according to the USDA-ERS data in Table 1. Out of that amount, it is assumed that 80 million bushels (13.7%) are used for food purposes and the remaining 493 million bushels used for non-food purposes. U.S. non-food corn exports over that same time period were 1,559 million bushels. U.S. non-food corn exports to Japan comprised 31.6% of all U.S. non-food corn exports.

Hence the downward shift of 9.6% caused by the additional IP costs must be applied to 31.6% of all U.S. non-food exports. This translates into an effective shift in the excess demand for U.S. non-food corn by 3%. Combining this result with the shift in the excess demand for U.S. food corn, results in an effective shift in the total excess demand schedule for U.S. corn of 4%.

To estimate actual monetary values using the model described above, the shapes of the U.S. supply and demand curves (S_T and D_T in Panel A of Figure 1) and the shape of the excess demand curve facing U.S. corn producers in international markets (ED_{US} in Panel B of Figure 1) must be specified. To obtain empirical estimates, these curves are assumed to be linear.[3]

To obtain empirical estimates, the intercept and the slope of the demand schedules (D_F, D_N, and D_T in Panel A of Figure 1) and the excess demand schedules facing the U.S. (ED_F, ED_N, and ED_{US} in Panel B of Figure 1) must be estimated. Estimates of these parameters can be obtained by specifying the elasticities and by using the actual prices and quantities that existed over the 1997/98–1999/2000 period. Following the modeling work of the USDA-ERS, the price elasticity of U.S. corn demand was estimated as falling between –0.3 and –0.5. In addition, Adams (1996) estimated a demand elasticity of –0.673. For this analysis, we use a value of –0.5, which is near the middle of this range. The elasticity of the excess demand for U.S. corn in international markets has not been estimated specifically. It is generally accepted that the excess demand elasticity for feed grains does not fall below –1.0. Some have suggested that it may be as high as –20 (Schmitz and Gray, 2000). A conservative estimate of the excess demand elasticity for U.S. corn exports of –2.0 is used for the most likely outcome described below.

Estimates of changes in U.S. corn markets, resulting from the introduction of IP costs for sales of food corn and for sales of non-food corn to Japan, are provided in Table 2. Consider the outcome associated with an IP cost of 19.75¢ per bushel, an elasticity of the domestic demand for all U.S. corn of –0.5, and an elasticity of the excess demand for all U.S. corn exports equal to –2.0. But for StarLink, during a typical marketing year (represented by 3-year average, 1997/98–1999/00) U.S. corn producers would have received an additional 10.18¢ per bushel, all else remaining equal. This translates into additional revenue of $964 million dollars. But for StarLink, domestic food sales would have been 125 million bushels higher and residual food sales would have been 47 million bushels higher.[4]

The second column of Table 2 under the IP costs of 19.75¢ per bushel represents the empirical results where the elasticity of demand for U.S. corn equals –2.0 and the elasticity of excess demand for U.S. corn exports is –5.0. The average price of corn received by all U.S. producers following the discovery of StarLink would have been 6.22¢ per bushel higher had StarLink not been discovered in the grain handling system, giving a loss of $589 million in aggregate revenue realized by all U.S. corn producers. Corresponding estimates were also obtained in the case in which IP costs are reduced to 10¢ per bushel. Under these scenarios, the average reduction in price induced by StarLink drops to 3.15¢ to 5.16 ¢ per bushel, which translates into estimated damages of $298 to $488 million for a typical marketing year immediately following StarLink.[5]

Adjusted for the LDP Program

The above estimates may seem somewhat high partly because the empirical results apply only in a typical marketing year during which no loan deficiency payment (LDP) is paid by the government to U.S. corn producers. However, the marketing year from September 1, 2000 through August 31, 2001 experienced unusually low corn prices that, at times, fell below the U.S. loan rate. From September 1, 2000 through August 31, 2001, LDP payments were made (Schmitz, Moss, and Schmitz, 2004). Hence, the estimates from Section IV must be adjusted to account for the dampening effect of the LDP.

The estimated changes in corn markets due to the IP costs due to StarLink are divided into 24 bimonthly periods. Each period is weighted by the corresponding value for total use. Each outcome in Table 2 is adjusted for the LDP and then aggregated over the entire marketing year to generate Table 3.

As a first example, consider the most likely outcome associated with an IP cost of 19.75¢ per bushel (Table 2, Column 1). This indicates a price drop of 10.18¢ per bushel for the 2000/2001 marketing year. However, Column 3 of Table 3 indicates that the average LDP rate was 17¢ per bushel for U.S. corn producers during the second period of October. Because this is higher than the losses attributed to StarLink in the absence of the LDP program, 604 million bushels of the total corn crop for the 2000/2001 marketing year (Table 3, Column 2) are estimated to have no effect on the actual price or revenue accruing to U.S. corn producers during that 2-week period.

As a second example, Table 3 indicates that in the second period of January 2001, the average LDP rate was 6¢ per bushel. The average price effect attributed to StarLink for the entire marketing year is 10.18¢ per bushel (from Table 2). Hence, the economic loss accruing to U.S. corn producers in the second period of January is equal to (10.18–6.00) or 4.18¢ per bushel. If this is multiplied by the approximate use of 325 million bushels (Table 3, Column 2), the economic loss to U.S. corn producers resulting from StarLink from January 16 through January 31, 2001 equals $19.5 million.

Note that in Table 5 sales are not affected by the LDP adjustment. Only the U.S. corn producers are affected by LDP payments. The only difference is that the U.S. government makes up some of the loss in market price induced by StarLink by paying corn producers extra money through LDP payments.

When adjusting for LDP payments, one likely outcome (Table 3, Column 1) indicates an average drop in the price that farmers actually received (which includes the price they receive from the market plus the LDP payments taken) of 3.04¢ per bushel. This results in an economic loss of $288 million dollars accruing to all U.S. corn producers as a result of the introduction of StarLink corn from September 1, 2000 through August 31, 2001. The LDP adjustments made for each of the other outcomes are also provided in Table 3. The impact ranges from 0.27¢ to 3.04¢ per bushel, which translates into losses of between $26 million and $288 million. Note that these numbers are much lower than those generated from the model that did not take the LDP program into consideration (Table 2).

Theoretical Framework (Structural Change in Demand)

In the following discussion, we model the impact of StarLink, assuming that the StarLink-contamination event caused a structural change in the import demand for U.S. corn from abroad. From September 1, 1999 through August 31, 2000, the United States exported 623 million bushels of corn to Japan. From September 1, 2000 through August 31, 2001, the United States exported only 573 million bushels of corn to Japan (USDA/FAS, 2004). Hence the Japanese import demand for U.S. corn dropped by 50 million bushels during the 2000 market year. This represents an estimated 7.95% reduction in the Japanese demand for U.S. corn exports induced by the StarLink-contamination event.[6]

In Figure 2, we illustrate a model with a structural change in import demand. In this framework, the LDP program is also considered. The excess demand curve of corn facing the United States ED, combined with the U.S. domestic demand curve D_d, gives total demand D_t. The U.S. supply curve of corn is S_{US}. Under free trade, corn production is q_f, domestic consumption is q_2, exports total q_1, and the free trade price is P_f.

Suppose the market price for corn falls below the loan rate (as it did at times during the 2000/01 marketing year) and the loan rate p_l is above the market price p_f. Production then increases to Q_l and exports and domestic consumption also increase. The market-clearing price for corn is p_m and the LDP is $p_l p_m ba.$ Assuming that the StarLink-contamination event caused the excess demand schedule to shift to ED', and assuming that planting decisions were already made so that supply does not adjust, the market price and the producer price both fall to p_n. However, even though the market price falls from p_m to p_n, the loan rate remains at p_l and producer welfare is not affected, because producers receive LDP payments in an amount of $p_m\ p_n\ b'\ b$ to totally offset the potential losses associated with a drop in prices. However, only during part of the period under investigation was the loan rate binding.

We use the parameters discussed in the previous model to carry out our analysis on the impact of the StarLink-contamination event. Following the modeling work of the U.S. Department of Agriculture, Economic Research Service (USDA/ERS), the price elasticity of U.S. corn demand is estimated at between –0.3 and –0.5 (USDA/ERS, 2004). In addition, Adams (1996) estimates a demand elasticity of –0.6. For the analysis in this study, a value of –0.5 is used for the medium-sensitivity outcome described below. Sensitivity analysis is also performed for demand elasticities of –0.3 and –2.0. An estimate of the excess demand elasticity for U.S. corn exports of –5.0 is used for the medium-sensitivity outcome described below. Sensitivity analysis is also performed for excess demand elasticities of –2.0 and –20.[7]

The Impact of StarLink (Structural Change in Corn Demand)

The Absence of the LDP Program

Estimates of the change in U.S. corn markets in a typical marketing year (represented by the 3-year average from 1997/98 through 1999/2000) resulting from the reduction in Japanese demand for U.S. corn exports caused by the StarLink-contamination event are provided in the first three columns of Table 4. The fourth outcome in Table 4, foreign demand, refers to the hypothetical case in which the demand for U.S. corn exports in all countries (not just in Japan) is reduced by 7.95%. The last outcome, foreign and U.S. food demand, refers to the hypothetical case in which the demand for U.S. corn exports in all countries is reduced by 7.95% and the demand for food corn within the United States is also reduced by 7.95%.

Japan's high-sensitivity outcome is based on a 7.95% reduction in Japanese demand for U.S. corn exports, a U.S. corn demand elasticity of –2.0, and an elasticity of U.S. residual export demand of –20. (This is a more conservative estimate of the true impact of reduced Japanese demand for U.S. corn.) But for the Starlink-contamination event, during a typical marketing year the average price received by all U.S. corn producers would have been U.S. 4.17¢ per bushel higher and U.S. corn producers would have received an additional U.S. $395 million in revenue, when compared to what they actually received over the 2000/01 marketing year. The quantity of U.S. food corn sold increased by 42 million bushels and domestic nonfood corn sold increased by 267 million bushels. This occurred because the StarLink-contamination event increased the supply of corn in the U.S. domestic market, since the United States was forced to sell less corn to the Japanese market. The StarLink-contamination event did not affect the total quantity of U.S. corn sold with respect to a typical marketing year in the first year immediately following the event, because the StarLink-contamination event occurred in September and the area of U.S. corn planted was pre-determined much earlier in the season.

Also provided in Table 4 (Columns 2 and 3) are the results associated with medium- and low-sensitivity demand curves in which the demand elasticities are made smaller. As the demand curves become more inelastic, the effect of the StarLink-contamination event on prices and producer revenue increases, while its effect on domestic food and nonfood sales diminishes. However, the corn price and revenue impacts do not change considerably as the demand curves become more inelastic.

In summary, reduced Japanese demand for U.S. corn caused by the StarLink-contamination event would have caused the price of corn received by U.S. producers to drop by between U.S. 4.17¢ per bushel to U.S. 5.18¢ per bushel. This drop in the price of corn received by U.S. farmers in 2000/01 would have reduced the aggregate revenue accruing to U.S. corn producers by between U.S. $395 and U.S. $491 million. However, as shown in the next section, the LDP program in the United States had a significant dampening effect on the magnitude of the changes in prices and revenue actually attributable to the StarLink-contamination event.

Scenario 2 is based on a 7.95% reduction in the aggregate excess demand for U.S. corn exports in the rest of the world, including Japan and all other countries. It assumes a domestic demand elasticity of –0.5 and an excess demand elasticity of –5.0. This is a hypothetical outcome that could represent the situation in which all countries would decide to import less U.S. corn because of the StarLink-contamination event. But for StarLink-contaminated corn, during a typical marketing year unadjusted for LDP the average price received by all U.S. corn producers would have been U.S. 13.82¢ per bushel higher and U.S. corn producers would have received an additional U.S. $1.3 billion in revenue.

The last outcome shown in Table 4 refers to the hypothetical situation in which the aggregate excess demand for U.S. corn exports in international markets is reduced by 7.95%, and the domestic demand for U.S. food corn is also reduced by 7.95%. To obtain results associated with a 7.95% reduction in the domestic demand for U.S. food corn alone, excluding feed corn, it is first necessary to differentiate between food and nonfood corn. StarLink-contaminated corn, for example, is acceptable for use in creating ethanol fuel. In addition, some companies have not restricted the use of StarLink-contaminated corn for high fructose corn syrup (HFCS), which is used mostly for making soft drinks, while other companies such as PepsiCo have. For the purposes of this study, food corn is defined as that corn contained in the food, seed, and industrial (FSI) category as defined by the USDA, minus the amount used for fuel, minus one-half of the amount used for HFCS because of the selectivity criteria used by soft-drink manufactures. Using this definition, the 3-year average quantity of food corn consumed in the United States from 1997 to 1999 was 1.05 billion bushels.

The 3-year average level of corn production from 1997/98 through 1999/2000 in the United States was 9,465 million bushels. Of this amount, 1,807 million bushels of food and nonfood corn were exported by the United States. Hence, 7,658 million bushels of corn were consumed in the United States. Of this amount, 1,050 million bushels were consumed as food corn, and 6,608 million bushels were consumed as nonfood corn. Hence, 13.7% (1,050 million bushels food corn consumption divided by 7,658 million bushels total U.S. consumption) of all corn consumed in the United States is considered food corn while the other 86.3% is considered nonfood corn.

The results associated with a reduction in both the domestic demand for U.S. food corn by 7.95% and the foreign import demand for both U.S. food and nonfood corn by 7.95% (Table 4, Column 5) show that StarLink-contaminated corn caused corn prices to fall by U.S. 15.83¢ per bushel higher.

Adjusted for the LDP Program

Estimates are given in Table 5 on the impact of the StarLink-contamination event, taking into account LDP payments. The five adjusted LDP outcomes in Table 5 correspond to the five outcomes in Table 4. The Table 5 results are discussed below and are compared with the results from Table 4.

In the presence of the LDP program, the 7.95% reduction in Japanese demand for U.S. corn exports caused by the StarLink-contamination event reduced the average price received by U.S. corn producers by between U.S. 0.5¢ and U.S. 0.83¢ per bushel, translating into lost revenue of only between U.S. $48 million and U.S. $78 million. In

2000/01, the LDP program essentially reduced by 88% the burden of the StarLink-contamination event that otherwise would have been passed on to U.S. corn producers (i.e., the adjusted numbers in Table 5 represent only 12% of the impact that the StarLink-contamination event would otherwise have had in the absence of a government program). A comparison of the last two columns in Tables 4 and 5 reveals similar results.

Conclusions

We have presented two models on estimating the impact of the well-published StarLink-contamination event. In our opinion, reasonable results can be obtained from either model. However, likely, the ideal model would incorporate both IP costs and structural changes in demand in the presence of StarLink. The results show that the results depend on the proper accounting of U.S. farm policy—the loan rate for corn.

The $110 million settlement reached in February 2003 falls within the range of our empirical estimates, even with the property damage claims of $10 million and legal fees estimated at approximately $44 million. An important point here is that because of the size of the U.S. corn crop (nearly 10 billion bushels), a $100 million drop in revenue represents only approximately a 1¢ per bushel reduction in the realized producer price over the 2000/2001 marketing year. However, this is the exact amount that corn loss claimants—those compensated for the alleged reduction in the general price of corn caused by StarLink—received under the settlement.

ENDNOTES

[1] It is important to point out that IP costs are a decreasing function of the degree of tolerance. In the StarLink case, the tolerance level for StarLink in corn exports into Japan and South Korea was close to zero. This makes segregation next to impossible, given the limitations of the production and handling processes. For example, if StarLink were present in concentrations of 0.2%, there would be a 99% probability that a lot of corn would be rejected using a 2,400-kernel sample size.
[2] In this model, we use a food to total consumption ratio of 13.7%. However, it has been suggested in an EPA White Paper that this ratio is closer to 23%. If this is the case, then our estimates of damages are conservative.
[3] In reality, these curves are most likely not linear. However, since we are dealing with small changes relative to the size of these markets, a linear curve represents a first-order mathematical and statistical approximation and has been used in a large number of studies that estimated the economic impact of shocks to market equilibrium.
[4] As more evidence of the reduction in U.S. corn exports to Japan induced by the introduction of IP costs due to StarLink, FASonline [http://www.fas.usda.gov/export-sales/myfiaug.htm] reports that actual U.S. corn exports to Japan from September 1, 2000 through August 31, 2001 were 573 million bushels. That same publication also reports that U.S. corn exports to Japan from September 1, 1999 through August 31, 2001 were 623 million bushels. This translates into a 9.2% reduction in actual U.S. corn exports to Japan from the year prior to the introduction of StarLink. This number is very close to the 9.6% shift in the export demand schedule induced by the 19.75¢ per bushel IP cost for U.S. exports of food and non-food corn to Japan, estimated in the above analysis.
[5] Results were also obtained for an IP cost of 29¢ per bushel. Although not shown, this would have decreased the price received by U.S. farmers by 14.95¢ per bushel, which translates into a loss of $1.5 billion in aggregate revenue.
[6] Unfortunately, in this type of partial-equilibrium analysis, one cannot hope to identify the true reduction in the Japanese residual-demand curve encountered by U.S. producers, since it would require the inclusion of all of the supply and demand functions for corn in all international markets. Therefore, in the absence of other information, 7.95% is only an estimate. The true reduction in Japanese corn demand caused by the StarLink-contamination event could possibly vary from this estimate.
[7] The analysis presented in this article is concerned with the impact of the StarLink-contamination event in the marketing year immediately following the discovery of StarLink corn in the food chain. Since U.S. producer-planting decisions must be made in the early part of the year, and StarLink corn was not discovered until the latter part of the year, there was insufficient time to allow a supply response to the StarLink-contamination event; thus the supply curve in this analysis is vertical. Results for a supply curve that is not perfectly inelastic (representing year 2) were calculated by the authors, but in the interest of brevity, are not included in this paper.

References

Bender, K., L. Hill, B. Wenzel, and R. Hornbaker. “Alternative Market Channels for Specialty Corn and Soybeans.” Department of Agricultural and Consumer Economics, Agricultural Experiment Station Document AE-4726. College of Agricultural, Consumer, and Environmental Sciences, University of Illinois at Urbana-Champaign, 1999.

Bullock, D. S., M. Desquilbet, and E. I. Nitsi. “The Economics of Non-GMO Segregation and Identity Preservation.” Mimeographed paper, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, October 2000.

European Union, Directorate-General for Agriculture. *Economic Impacts of Genetically Modified Crops on the Agri-Food Sector* http://europa.eu.int/comm/agriculture/publi/gmo/fullrep/index.htm.

Gardner, B.L. “Pre- and Post- FAIR Act Comparisons.” Paper presented at the Conference in Honor of Luther Tweeten, Ohio State University, Columbus, OH, 2000.

Just, R.E., D.L. Hueth, and A. Schmitz. *Applied Welfare Economics and Public Policy*. Englewood Cliffs, NJ: Prentice-Hall, 1982.

Lin, W. H., W. Chambers, and J. Harwood. “Biotechnology: U.S. Grain Handlers Look Ahead.” *Agricultural Outlook*, USDA/Economic Research Service, April 2000.

Lin, W., G.K. Price, and E. Allen. “StarLink Impacts on the U.S. Corn Market and World Trade.” *Food Situation and Outlook Yearbook*. USDA-ERS, FDS-2001, Washington, D.C., April 2001.

Lin, W., G.K. Price, and E. Allen. “StarLink: Where No CRY9C Corn Should Have Gone Before.” *Choices* (Winter 2001-2002):31–33.

Maltsbarger, R., and N. Kalaitzandonakes. “Study Reveals Hidden Costs in the IP Supply Chain.” Economics & Management Center, University of Missouri-Columbia, September 2000a.

Maltsbarger, R., and N. Kalaitzandonkes. “Study Reveal Hidden Costs in IP Supply Chain.” *Feedstuffs* 72 (August 28, 2000b):36.

Moschini, G., H. Lapan, and A. Sobolevsky. “Roundup Ready Soybeans and Welfare Effects in the Soybean Complex.” *Agribusiness* 16 (1, 2000):33–55.

Moss, C. B., and A. Schmitz. “Vertical Integration and Trade Policy: The Case of Sugar,” *Agribusiness: An International Journal* 18 (1, 2002):49-60.

Robinson, M. “Judge Approves $9 Million Settlement in StarLink Lawsuit.” *Associated Press*, March 7, 2002.

Schmitz, T.G., and R. Gray. “State Trading Enterprises and Revenue Gains from Market Power: The Case of Barley Marketing and the Canadian Wheat Board.” *Journal of Agricultural and Resource Economics* 25 (2, 2000):596–615.

Schmitz, T.G., A. Schmitz, and C. Dumas. “Gains from Trade, Inefficiency of Government Programs, and the Net Economic Effects of Trading.” *Journal of Political Economy* 105 (3, 1997):637–647.

Schmitz, T.G., C.B. Moss, and A. Schmitz. “Differentiating GMO and Non-GMO Commodites: Effects of Government Programs on Market Segmentation.” *The Regulation of Agricultural Biotechnology*. R.E. Evenson and V. Santaniello, eds. Wallingford, UK: CABI Publishing, forthcoming.

Uchtmann, D.L. “StarLink – A Case Study of Agricultural Biotechnology Regulation.” Drake Journal of Agricultural Law 7 (2002):160-208.

***Table 1. Supply and Use of Corn in the U.S. (1980/81-1999/00)* in Millions of Bushels**

Year	Production	Exports	Feed	FSI	Domestic Use	Food**	Non-Food****
1980/81	6,639	2,391	4,232	659	**4,248**	542	3,707
1981/82	8,119	1,997	4,245	733	**6,122**	556	5,566
1982/83	8,235	1,821	4,573	854	**6,414**	607	5,807
1983/84	4,174	1,886	3,876	930	**2,288**	638	1,651
1984/85	7,672	1,850	4,115	1,067	**5,822**	680	5,142
1985/86	8,875	1,227	4,114	1,152	**7,648**	718	6,931
1986/87	8,226	1,492	4,660	1,233	**6,734**	774	5,960
1987/88	7,131	1,716	4,789	1,252	**5,415**	794	4,621
1988/89	4,929	2,028	3,934	1,298	**2,901**	831	2,070
1989/90	7,532	2,367	4,383	1,370	**5,165**	865	4,300
1990/91	7,934	1,727	4,609	1,425	**6,207**	887	5,321
1991/92	7,475	1,584	4,798	1,534	**5,891**	940	4,951
1992/93	9,477	1,663	5,252	1,556	**7,814**	923	6,891
1993/94	6,338	1,328	4,680	1,609	**5,010**	929	4,081
1994/95	10,051	2,177	5,460	1,705	**7,874**	940	6,934
1995/96	7,400	2,228	4,693	1,612	**5,172**	975	4,197
1996/97	9,233	1,797	5,277	1,692	**7,436**	1,011	6,425
1997/98	9,207	1,504	5,482	1,782	**7,703**	1,035	6,668
1998/99	9,759	1,981	5,472	1,860	**7,778**	1,038	6,740
1999/00	9,431	1,937	5,664	1,913	**7,494**	1,078	6,416
1997-99* **	**9,465**	**1,807**	**5,539**	**1,852**	**7,658**	**1,050**	**6,608**

*The crop year begins September 1 and ends on August 31.
**For the purposes of this study, food corn is defined as Food, Seed, and Industrial use (FSI), minus the amount used as fuel, minus ½ of the amount used for High Fructose Corn Syrup (HFCS).
***3-year unweighted average of 1997/98 through 1999/00 crop years.
****The USDA breaks down domestic use in terms of Feed and FSI. For the purposes of this study, domestic use is separated into Food and Non-Food Use.
Domestic Use is computed as the difference between U.S. production and exports.
Source: Feed Situation and Outlook Yearbook, Market and Trade Economics Division, ERS-USDA, Various Issues.

Table 2. Impact of StarLink (Not Adjusted for LDP Payments)[a]

IP Cost (¢/bu)	19.75		10.00	
	Most Likely[b]	*Sensitivity Analysis*[c]	*Most Likely*[b]	*Sensitivity Analysis*[c]
Corn Price (¢/bu)	-10.18	-6.22	-5.16	-3.15
Revenue (mil $)	-964	-589	-488	-298
Domestic Food Sales (mil bu)	-125	-238	-63	-121
Residual Food Sales (mil bu)	-47	-105	-24	-53
Domestic Non-Food Sales	163	399	83	202
Residual Non-Food Sales	8	-56	4	-28
Total Sales (mil bu)	0	0	0	0

[a]Changes are estimated using average market conditions from (1997/98-1999/00) to represent a typical marketing year.
[b]U.S. corn elasticity demand = -0.5; U.S. corn export elasticity excess demand = -2.0.
[c]U.S. corn elasticity demand = -2.0; U.S. corn export elasticity excess demand = -5.0.

Table 3. Impact of StarLink in 2000/2001 (Adjusted for LDP Payments)[a]

IP Cost (¢/bu)	19.75		10.00	
	Most Likely[b]	*Sensitivity Analysis*[c]	*Most Likely*[b]	*Sensitivity Analysis*[c]
Corn Price (¢/bu)	-3.04	-1.19	-0.82	-0.27
Revenue (mil $)	-288	-112	-78	-26
Domestic Food Sales (mil bu)	-125	-238	-63	-121
Residual Food Sales (mil bu)	-47	-105	-24	-53
Domestic Non-Food Sales	163	399	83	202
Residual Non-Food Sales	8	-56	4	-28
Total Sales (mil bu)	0	0	0	0

[a]Changes are estimated using average market conditions from (1997/98-1999/00) to represent a typical marketing year.
[b]U.S. corn elasticity demand = -0.5; U.S. corn export elasticity excess demand = -2.0.
[c]U.S. corn elasticity demand = -2.0; U.S. corn export elasticity excess demand = -5.0.

Table 4: StarLink-Contamination Event: A 7.95% Reduction in Demand for U.S. Corn: 2000/01[a]

	Japanese Demand			Foreign Demand[c]	Foreign and U.S. Food-Corn Demand[c]
	High Sensitivity[b]	*Medium Sensitivity[c]*	*Low Sensitivity[d]*		
Corn Price (¢/bu)	–4.17	–4.76	–5.18	–13.82	–15.83
Producer Revenue (U.S. mil $)	–395	–451	–491	–1,309	–1,499
			Millions of Bushels		
Domestic Food Sales	42	12	8	35	–85
Residual Food Sales	–42	–12	–8	-35	–23
Domestic Nonfood Sales	267	76	50	221	254
Residual Nonfood Sales	–267	–76	–50	–221	–146
Total Sales	0	0	0	0	0

[a]Changes are estimated using average market conditions from 1997/98 through 1999/2000 to represent a typical marketing year (*ceteris paribus*).
[b]The high-sensitivity scenario is associated with an aggregate U.S. corn demand elasticity of –2.0 and an elasticity of U.S. residual export demand of –20.
[c]These medium-sensitivity scenarios are associated with an aggregate U.S. corn demand elasticity of –0.5 and an elasticity of U.S. residual export demand of –5.
[d]The low-sensitivity scenario is associated with an aggregate U.S. corn demand elasticity of –0.3 and an elasticity of U.S. residual export demand of –2.

Table 5: StarLink-Contamination Event: A 7.95% Reduction in Demand for U.S. Corn Adjusted for LDP Payments, 2000/01[a]

	Japanese Demand			Foreign Demand[c]	Foreign and U.S. Food-Corn Demand[c]
	High Sensitivity[b]	*Medium Sensitivity*[c]	*Low Sensitivity*[d]		
Corn Price (¢/bul)	–0.50	–0.69	–0.83	–5.21	–6.47
Producer Revenue (U.S. mil $)	–48	–65	–78	–493	–613
		Millions of Bushels			
Domestic Food Sales	5	2	1	13	–35
Residual Food Sales	–5	–2	–1	–13	–9
Domestic Nonfood Sales	32	11	8	83	104
Residual Nonfood Sales	–32	–11	–8	–83	–60
Total Sales	0	0	0	0	0

[a]Changes are estimated using average market conditions from 1997/98 to 1999/2000 to represent a typical marketing year (*ceteris paribus*).

[b]The high-sensitivity scenario is associated with an aggregate U.S. corn demand elasticity of –2.0 and an elasticity of U.S. residual export demand of –20.

[c]These medium-sensitivity scenarios are associated with an aggregate U.S. corn demand elasticity of –0.5 and an elasticity of U.S. residual export demand of –5.

[d]The low-sensitivity scenario is associated with an aggregate U.S. corn demand elasticity of –0.3 and an elasticity of U.S. residual export demand of –2.

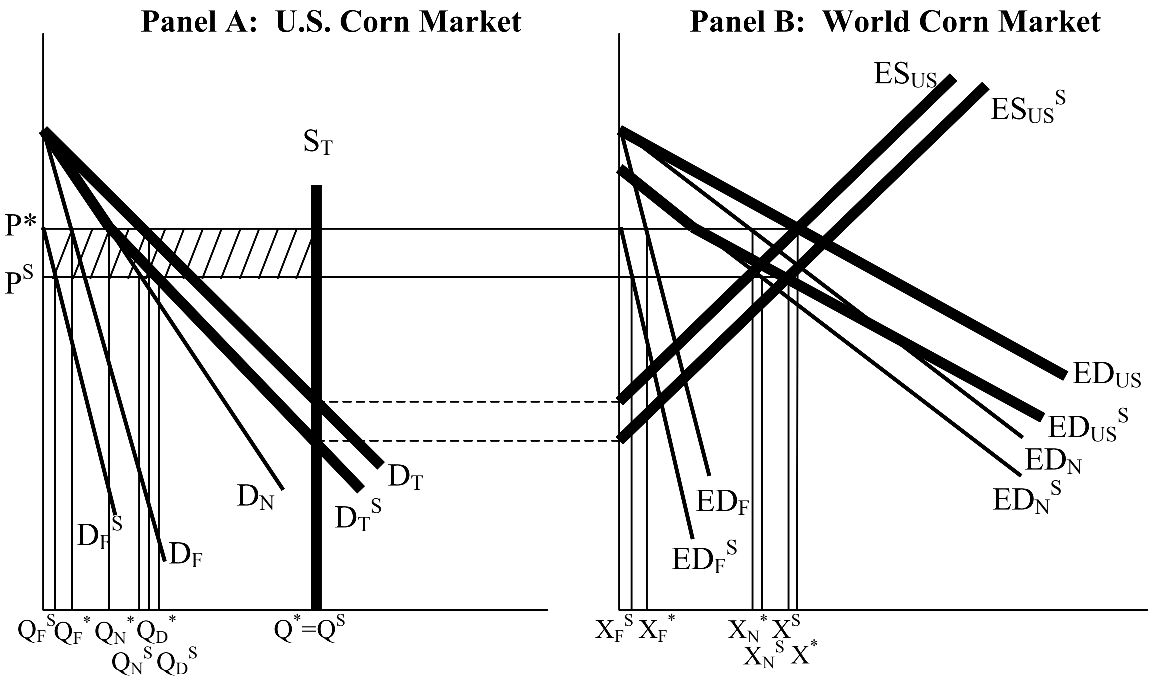

Figure 1. Economic Impact of StarLink on Domestic and International Corn Markets
Represents Year 1 calculations with no supply response (vertical supply)

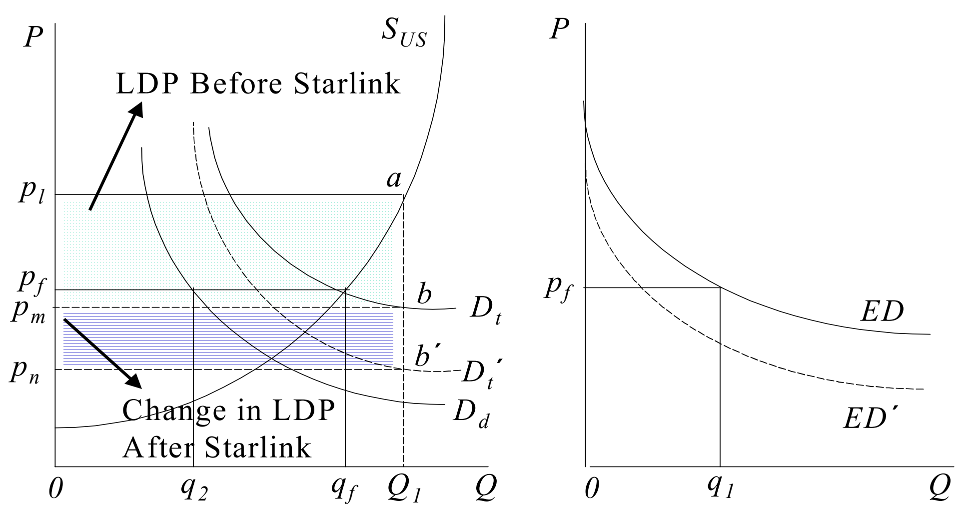

Figure 4. Loan Rates and Structural Demand Changes