StarLink: Impacts on the U.S. Corn Market and World Trade*

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Abstract: StarLink disrupted the U.S. corn market during the marketing year of 2000/01 as a result of inadvertent commingling. The potential volume of marketed StarLink-commingled corn from the 2000 crop located in areas near wet and dry millers prior to October 1, 2000, is estimated at 124 million bushels. Price differentials between StarLink-free and StarLink-commingled corn existed during the early stage of the incident, but eroded quickly. While StarLink has had a negative impact on U.S. corn exports, most of the reduction in exports to Japan and South Korea during November 2000 and March 2002 is due to Japan's increased purchases from South Africa, China's decision to continue to subsidize exports, increased competition from the large back-to-back crops in Argentina, and a record Brazillian crop.

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StarLink corn was developed by Aventis CropScience (Aventis), a multinational firm based in France.[1] This biotech corn crop contains the gene from the soil bacterium *Bacillus thuringiensis* (Bt) which produces a protein, Cry9C, that is toxic to European corn borers and certain other insect pests. The Bt variety was grown earlier by some producers in 1998 and 1999. By 2000, it accounted for less than 1 percent of the total U.S. corn acreage (about 362,000 acres), with 40 percent of the acreage concentrated in Iowa.

On September 18, 2000, a news headline reported that some taco shells sold in retail stores contained a protein from StarLink corn, which was approved only for feed and non-food industrial uses but not for human consumption. The U.S. Environmental Protection Agency (EPA) did not approve the Cry9C protein for human consumption due to lingering questions about the protein's potential to cause allergic reactions. A testing lab indicated that it found the presence of the Cry9C protein in a sample of Taco Bell taco shells.

This discovery led to a series of recalls of food products. Kraft Foods, Inc., the company that produced the taco shells, recalled all of its taco shells after further testing by the Food and Drug Administration confirmed the initial results. The incident led to the recall of nearly 300 food products, including more than 70 types of corn chips, more than 80 kinds of taco shells, and nearly 100 food products served in restaurants. The recall did not necessarily reflect that StarLink corn had been found in all these products, but was a precaution taken by manufacturers of these foods. A few months later, StarLink was found in more corn products, including corn dogs, corn bread, polenta, and hush puppies.

The incident illustrates the complexity of isolating crop varieties within the existing grain marketing system and preventing unwanted commingling.[2] The potential commingling of StarLink with other corn varieties was exacerbated by three factors: (1) corn grown on the buffer zone was probably cross-pollinated with StarLink corn,[3] (2) a portion of StarLink corn (including that grown on the buffer zone) had entered the marketplace prior to an effort to contain StarLink-commingled corn, and (3) some elevators did not know that 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.[4]

To contain the extent of commingling, Aventis reached an agreement with the U.S. Department of Agriculture (USDA) on September 29, 2000, to launch a buyback program. This program offers producers a 25-cents-per-bushel premium above the posted-county price to ensure that StarLink corn is fed to farmers' own animals, sold to feed outlets, or sold to the Commodity Credit Corporation (CCC), with the expenses (including extra transportation charges) being reimbursed by Aventis.[5] This program, however, did not address the 1998, 1999, and 2000 StarLink corn crops that had already been delivered to local elevators.[6] In November 2000, the U.S. and Japanese Governments reached an agreement that establishes testing protocols, which would be implemented through sales contracts, for detecting StarLink in U.S. food corn shipments to Japan. Then, in January 2001, Aventis reached an agreement with 17 State (including Iowa) Attorneys General to expand compensation coverage to grain elevators (Harl *et al*.).

Early in fall 2000, Aventis voluntarily withdrew the registration for StarLink, in effect removing the variety from the marketplace for 2001-crop plantings. USDA also worked with the seed industry to ensure that hybrid corn seed sold and planted in 2001 was tested for the presence of the Cry9C protein. To further support this effort, Aventis and USDA reached an agreement in March 2001 to launch a seed corn buyout program that would purchase seed containing Cry9C from seed companies.

While concern over the StarLink incident has subsided, the recent media reporting of Monsanto's canola seed being commingled with genetically modified material that is not federally approved has rekindled interests in lessons we have learned from the incident. Emerging pharmaceutical biotech products (such as the biotech corn that contains a protein found on the surface of HIV, which could serve as an edible AIDS vaccine being developed by ProdiGene Inc. in Texas) also pose a similar issue of containing these products from entering into the grain handling system and food supply chain. The main purpose of this paper is to attempt to assess the magnitude of the impacts of the StarLink incident on the U.S. corn market and global corn trade. Specifically, the objectives are: (1) to examine the disruptions caused by the incident in the domestic and export corn markets, (2) to estimate the potential (upper-bound) volume of StarLink-commingled corn from the 2000 crop that was produced and marketed near wet- and dry-milling facilities, and (3) to estimate the impact of StarLink on global corn trade and U.S. corn exports.

Disruptions in the Domestic Corn Market

Disruptions in the U.S. corn market occurred as a result of commingling when shipments destined for food use or export markets tested positive for StarLink and had to be rerouted to approved uses. The market disruption has been kept to a minimum by directly channeling the commingled corn to feed use, which accounts for about 60 percent of U.S. corn disappearance (USDA, 2000a). Alternatively, commingled corn has been channeled to certain non-food industrial users, such as dry-mill ethanol plants where the byproduct feeds produced are typically consumed domestically. Dry-mill alcohol fuel use accounts for about 2 percent of corn disappearance.

In response to the potential commingling of StarLink with other corn in shipments, local elevators owned by large grain companies (own and operate both grain handling and processing facilities) are conducting StarLink tests on corn shipments. Also, some other local elevators, which normally do not test for the presence of biotech content in corn shipments, are conducting StarLink tests as well because of compensation provided by Aventis.[7]

Food processors (including corn dry and wet millers) are testing inbound corn delivered to their facilities. In the case of wet milling, the Cry9C protein is retained in gluten meal and feed, but not in starch, oil, or corn syrup, which are intended for human consumption (EPA). In contrast, the Cry9C protein can be detected in dry-mill products, including corn meal, corn flour, and corn grits, because the process does not remove the protein from the products. Hence, Aventis has made test kits available to dry millers for detecting the presence of Cry9C in corn shipments.

When corn shipments are rejected by processors, arrangements must be made to alter grain flow patterns by hauling the grain away from processing facilities or export ports to feed or non-food industrial users. Rerouted shipments of rejected corn impose extra transportation costs on grain elevators. Compensation by Aventis for any extra transportation costs is possible if the expenses are documented (Harl *et al.*). In most cases, rerouting of the rejected grain involves shipment to destinations not far away from the originally intended destination. Demurrage, a charge for detaining a truck or freight car resulting from the rerouting the StarLink-commingled corn to approved delivery destinations, adds an extra cost for grain elevators.

The extent to which corn shipments tested positive is an indicator of the degree of disruptions in the corn market. According to the grain industry, the percentage of corn shipments tested positive ranges from 5 percent to 10 percent. However, most corn shipments testing positive for StarLink exhibited relatively low concentrations. Also, this percentage of corn shipments tested positive varies by mode of transportation. In the case of truck shipments, the percentage of shipments tested positive averaged about 5 percent. In contrast, the percentage was lower for barge shipments, which are primarily destined for export markets, because many river elevators conducted StarLink tests to avoid shipments of StarLink-commingled corn to export markets. The percentage of rail shipments that tested positive, on other hand, was higher than that for truck shipments. Since late 2001, only a tiny fraction of corn shipments has tested positive.

The zero tolerance for unapproved biotech varieties adopted by domestic food processors and buyers in major export markets (mainly Japan) raises the question of whether it is technically feasible for the grain industry to segregate crop supplies consistent with this tolerance. Segregation poses logistical problems for grain transportation. Corn is commonly transported to export elevators in unit trains of up to 100 cars (or by barge). If effectively maintaining crop segregation makes it necessary to shift transportation away from unit trains to individual railcars, transportation costs could increase significantly. One industry source suggests that if the threshold for biotech content was 1 percent or lower, transportation costs could potentially double (Lin *et al*.). The cost of segregating non-biotech corn was estimated to be around 22 cents per bushel (12 percent of the average farm price of corn or about $9 per metric ton) from country elevators to export ports if segregation follows the handling process for high-oil corn, which typically meets a tolerance level of about 5 percent for Japanese market (Lin). A sale of segregated non-biotech corn to South Korea in spring 2001 suggests a lower cost of segregation at 18 cents per bushel (about $7 per metric ton). However, segregation to meet zero tolerance is virtually impossible.

Potential price discounts for StarLink corn shipped by grain handlers are another disruption in the corn market. According to trade sources, price differentials between StarLink and StarLink-free corn ranged between 7 and 12 cents per bushel (or 4-6 percent of the U.S. average corn price received by farmers) and, in some rare instances, reached as high as 15 to 20 cents during the early stage of the incident. Compensation by Aventis for any market losses (besides any extra transportation costs) is possible if they are documented (Harl *et al*.). Price discounts for StarLink corn reportedly were widespread, especially in the Southeastern poultry market and export markets. However, trade volume for discounted StarLink-commingled corn in the domestic market was very thin, especially in those areas commanding larger price differentials.

Premiums for StarLink-free corn eroded quickly for several reasons. First, the U.S. grain handling industry became more knowledgeable in addressing the issues. As more destinations for channeling were approved, StarLink corn found more market outlets for delivery. Second, several agreements involving the Federal and State governments paved the way to channel StarLink corn to approved uses. These agreements include the Aventis-USDA agreement on the buyback program in late September 2000 which directs the commingled corn to feed or non-food industrial use, the agreement made by the U.S. and Japanese Governments in November 2000 to establish testing protocols to resolve related trade issues, and the Aventis-17 State Attorneys General agreement reached in January 2001 to extend compensation coverage to grain elevators for additional testing and transportation expenses. Third, premiums for StarLink-free corn were also reduced as buyers were able to source StarLink-free corn. Finally, many grain companies did not discount StarLink corn prices paid to producers and handlers because Aventis paid the cost of diverting the grain to approved uses. Ever since spring 2001, the price differentials to producers and handlers have been small or nonexistent. At present, there is virtually no price differential.

Estimating the Potential Volume of StarLink-Commingled Corn

This section discusses the estimation of the potential volume of StarLink-commingled corn from the 2000 crop that was produced and marketed near wet- and dry-milling facilities.[8] The assumptions of the scenario analysis and the data sources will be discussed first, and then the results of the estimation for both wet- and dry-milling facilities will be presented. The results from this scenario analysis are only one of many possible outcomes, which vary depending on the assumptions and procedures used. The findings from this study are not intended to reflect the actual or most likely volume of commingled corn, but should be interpreted as an upper-bound estimate.

Scenario Development

The Aventis-USDA StarLink buyback program, announced on September 29, 2000, aimed to contain StarLink and commingled corn at the farm gate. That is, the program covered corn that had been harvested but not marketed, as well as corn that had yet to be harvested. The buyback program, however, did not address commingled corn that had already been marketed. As a result, the potential for commingling StarLink with other varieties existed in areas near wet- and dry-milling facilities.[9]

To determine the potential volume of StarLink-commingled corn from the 2000 crop in areas near wet- and dry-milling facilities, this study analyzes county-level production and marketing data to identify local "hot spots." Hot spots are defined as areas where large StarLink acres were planted or significant amounts of commingled corn were marketed near wet- and dry-milling plants. A high concentration of StarLink acreage may have contributed to significant commingling. Moreover, commingling may have occurred in areas with large corn production even though StarLink acreage was relatively small. The potential for commingling could be greater in certain locations where the proportion of the corn crop harvested by October 1, 2000, was higher than in other areas. For example, States in the South harvest their crop in August, thus potentially moving corn (StarLink and other varieties) into the grain handling system before the buyback program began.

Data and Methodology

The locations of corn wet- and dry-milling facilities were obtained from the Corn Refiners Association and the *Grain and Milling Annual* (Sosland Publishing Co.), respectively. Based on the geographic information, county-level data on harvested corn acreage and yields in 2000 were gathered from the USDA's National Agricultural Statistics Service (USDA, 2001$_a$). The potential volume of StarLink-commingled corn is estimated at the "greater-county" level, which is defined as the county in which one or more wet or dry millers are located as well as the adjacent counties within the same State. Greater-county area production is the sum of corn production in the specified counties. Multi-county corn production that had been harvested and marketed (including StarLink and other varieties) prior to October 1, 2000, was estimated by multiplying the greater-county corn production by the estimated percent harvested in the area (USDA, 2001_a) and by the estimated percentage marketed up to that date in 1999/00 (State-level data), which is the latest available USDA data on the distribution of corn sales (USDA, 2000_b). The volume of marketed StarLink corn by county (including the corn grown on the buffer zone) was obtained from Aventis' survey of StarLink producers. The acreage, production, and marketing data employed in this analysis are provided in table 1.

For illustrative purposes, Linn County, Iowa, is used as an example to show how the volumes of 2000-crop corn (3.9 million bushels) and StarLink (324,400) sold by October 1, 2000, were estimated for a greater-county area. The counties that surround Linn County are Buchanan, Delaware, Benton, Jones, Cedar, Johnson, and Iowa Counties. The 2000 harvested acreage in the greater Linn County area (1.1 million acres) consisted of 136,100 acres in Linn County and 978,700 in the other counties. Corn production in each county was computed by multiplying the county's 2000-crop harvested acreage by its average corn yield that year. Much of the estimated volume of corn in the greater Linn County area (161 million bushels) came from the surrounding counties (141.7 million bushels), while only 19.3 million bushels were produced in Linn County itself. To calculate the estimated volume of corn sold by October 1, 2000, in this greater-county area, the regional production was multiplied by the estimated percent harvested in the area prior to that date, which was about 27 percent. Then, that value was multiplied by the estimated share of corn sold up to that date (9 percent) based on 1999/00 marketing year sales data. The 324,400 bushels of marketed StarLink and buffer-zone corn were obtained from Aventis.

We assumed that the StarLink corn marketed prior to October 1, 2000, in a greater-county area was commingled with other corn from the area sold before that date. The volume of potentially commingled conventional corn (excluding StarLink and buffer-zone corn) in a given area was calculated as the difference between the total volume of corn marketed and the volume of StarLink corn sold by October 1, 2000 (table 2). For example, in the greater Linn County area, the 3.6 million bushels of potentially commingled corn was calculated by subtracting the 324,400 bushels of marketed StarLink from the 3.9 million bushels of total corn sold by October 1, 2000 (table 1). A commingling ratio—the estimated volume of the potentially commingled corn relative to the volume of marketed StarLink corn—was computed for each greater-county area where one or more processing facilities are located.

Results

This section presents, for illustrative purposes, the possible results in terms of the potential commingling of StarLink with conventional corn in areas near wet- and dry-milling facilities if the assumptions of the scenario analysis hold. The analysis identified seven greater-county areas across the States that had StarLink sales prior to October 1, 2000, that were estimated to be greater than 100,000 bushels. The greater-county area around Nebraska's Butler County marketed the largest amount of StarLink at 528,000 bushels (table 1). Other regions with large volumes of marketed StarLink corn include the greater Linn (Iowa), Lancaster, Washington, and Saline (Nebraska), Castro (Texas), and Atchison (Kansas) county areas.

This analysis identifies a number of hot-spot areas near processing facilities where large volumes of potentially commingled corn existed prior to October 1, 2000. Not surprisingly, most of the hot spots are in the Midwest (especially Iowa and Illinois) and other neighboring States, such as Nebraska, Tennessee, and Kentucky (table 2). Overall, the potential volume of marketed commingled corn from the 2000 crop located in areas near wet and dry millers prior to October 1, 2000, is estimated at 123.8 million bushels, or about 1.2 percent of the 2000 crop. The actual volume of commingled corn may differ from the potential volume estimated in this study.

In Iowa, where 40 percent of the StarLink corn was grown (Harl *et al.*) and seven wet millers and one dry miller are located, the volume of potentially commingled corn was found to be large in a few greater-county areas—Linn (3.6 mil. bu), Clinton (2.3 mil. bu.), and Mahaska (2.6 mil. bu.). In Iowa alone, the volume of potentially commingled corn in the greater-county areas is estimated to have reached 11.4 million bushels, which is nearly 20 percent larger than the 9.6 million bushels of U.S. StarLink and buffer-zone corn marketed in the U.S. prior to October 1, 2000 (Aventis). Other greater-county areas with large amounts of potentially commingled corn include regions in Illinois (Macon, Kankakee, Vermilion, and Tazewell), Tennessee (Madison), Nebraska (Butler, Saline, and Lancaster), Kentucky (Henderson and Christian), and Texas (Castro).

This county-level scenario analysis does not address the risk of commingling StarLink corn with other varieties outside of these counties. Furthermore, the scenario analysis does not address possible intrastate and interstate corn shipments beyond the surrounding counties because of a lack of information about current grain flow patterns. These shipments could compound the risk of commingling StarLink corn with other varieties in the grain handling system. However, some elevators can directly unload corn onto vessels, which lowers the risk of commingling.

The 123.8 million bushels of the commingled corn identified above applies only to the 2000 crop and refers to the potential volume of commingled corn that could have been marketed near wet and dry millers. Alternatively, the volume of commingled corn could be estimated at grain handling facilities. In a separate study, Aventis estimated that the commingled corn from the 1999 and 2000 crops exceeded 430 million bushels (Wichtrich). Most of this estimated volume of commingled corn came from the 1999 crop, which entered the grain handling system undetected throughout the entire marketing year. According to an Aventis spokesperson, the estimate was derived from information that the company gained from individual grain handlers' reports on the positive detection of Cry9C protein in their grain supplies. Those grain handlers contacted Aventis for assistance in directing the corn to approved animal feed and nonfood industrial uses.

Effects of StarLink on Global Grain Trade and U.S. Corn Exports

Restrictions imposed on the use of StarLink corn in some major U.S. export markets, such as Japan and South Korea, appear to have had a negative impact on U.S. corn exports. The zero tolerance for StarLink (which applies to any use of corn in Japan and food use in South Korea) and discrepancies over testing protocol at times disrupted corn shipments destined for these export markets during the marketing year of 2000/01.

Disruptions in U.S. Corn Exports

There is evidence that the presence of StarLink in U.S. corn exports temporarily disrupted shipments to Japan and South Korea during the first half of 2000/01. The first wave of disruptions occurred during late October and November 2000 before the U.S. and Japanese Governments reached an agreement on testing protocols to be implemented through sales contracts (fig. 1).[10]

The disruption continued into the next few months as discrepancies over StarLink testing results arose. U.S. corn exports to Japan from September 1 to the week ending December 28, 2000, for example, were down about 11 percent from a year earlier (USDA, 2000 & 2001). This decline was narrowed to about 7 percent by mid-April 2001 and then widened to about 10 percent by mid-July 2001. Outstanding sales of U.S. corn to Japan at the end of calendar year 2000 were down about 21 percent from a year earlier. The gap widened to 44 percent by mid-April but closed by mid-July 2001 (fig. 2). Accumulated U.S. corn exports and outstanding sales to Japan together were down about 1 million metric tons from a year earlier, as of August 30, 2001 (the end of the U.S. 2000/01 marketing year), a decline of 6 percent.[11]

In contrast, U.S. corn exports to South Korea from September 1 to the end of 2000 were down even more from a year earlier, reaching a decline of 55 percent. The decline subsided in early 2001, and was over 30 percent by mid-April 2001. U.S. corn exports (including feed and non-feed corn exports) to South Korea during the 2000/01 marketing year exceeded those a year earlier by 0.5 percent. Accumulated U.S. corn exports and outstanding sales to South Korea together were up 3 percent from a year earlier as of August 30, 2001. However, U.S. corn export sales to South Korea during the last year-and-half (from 9/00 to 4/02) were down by 1 million tons during the period of 9/99-4/01 as a result of South Korea's switching its non-feed corn sourcing from the United States to Brazil.

The StarLink incident is one of several factors that have contributed to the rearrangement of trade flow patterns on the world corn market. While the incident appeared to be an important factor, a more significant factor in the decrease of U.S. exports was global supply (e.g., larger than anticipated corn crops and exports from Brazil and Argentina). There was a modest gain in market diversion from food corn exports to Japan to other export markets that traditionally have purchased corn from Brazil, such as Middle East, Spain (not a U.S. export market), South Africa, and Far East. A record Brazilian corn crop in the 2000/01 marketing year made its corn more price competitive (despite availability of U.S. corn). However, the gain in market diversion could be greater as a result of diverting U.S. corn that was not sold to Japan and Korea for food use to markets that traditionally have not purchased corn from Brazil.

Trade Effects

The markets most affected by Starlink have been those for non-feed corn in Japan and South Korea. Import statistics from Japan and South Korea show a sizeable decline in the U.S. share of corn imports that are purchased for non-feed use. From November 2000 through October 2001, Japan’s imports of U.S. corn for starch manufacturing were down 39 percent from a year earlier, a decrease of 1.4 million tons. The decrease continued into a 40-percent from November 2000 through March 2002, or a drop of 1.9 million tons (table 3). As a result, U.S. share of corn imports into Japan for starch use declined from

93 percent during 11/99-3/01 to 62 percent during 11/00-3/02. Meanwhile, imports for starch from non-U.S. origins, including South Africa, China, Argentina and Brazil, increased from about 0.1 in the 11/99-3/01 period to 1.7-1.9 million tons during 11/00-3/02, depending on whether the category "not elsewhere specified" is included.

Similarly, South Korea's imports of U.S. corn for food manufacturing (mostly starch) during this same period (11/00-3/02) were down 48 percent from a year-and-half earlier, a decline of about 1.0 million tons (table 3). U.S. share of corn imports by South Korea for non-feed uses declined from 76 percent a year-and-half earlier to 40 percent. Virtually all the decline was offset by imports from non-U.S. origins for food manufacturing; these imports more than double their year-and-half-earlier levels. As indicated earlier, as of August 30, 2001, cumulative U.S. corn exports and outstanding sales together to South Korea for *all* uses during the 2000/01 marketing year were actually ahead of a year earlier, recovering U.S. corn export losses to this country incurred during the first half of 2000/01. However, as of April 25, 2002, U.S. corn exports to South Korea over the last year-and-half declined by about 1.0 million tons, a decline of nearly 20 percent, compared with the year-and-half earlier level. The decrease reflects the fact that South Korea increased its non-feed corn sourcing from Brazil at the expense of the United States over the last 6 months.

Competing exporters' trade data from November 2000 to March 2002 give similar results. During this period, Japanese buyers purchased additional corn for food processing from South Africa--about 700,000 tons--mostly from the large crop harvested in 2000.[12] Similarly, larger than anticipated corn exports from China--an additional 270,000 tons to Japan for starch use--also contributed to the decline in U.S. corn exports to Japan. Despite a drought-reduced crop, China decided to continue to subsidize exports (a decision not related to StarLink) during 2000/01 over the year-earlier level.[13] However, China substantially reduced its corn exports to Japan and South Korea during the first quarter of 2002, a direct result of its commitment to discontinue its corn export subsidies after joining the World Trade

Organization. In addition, Japanese buyers purchased additional corn for starch manufacturing over the last year-and-half from Brazil (528,000 tons) and Argentina (242,000 tons).

While StarLink has had a negative impact on U.S. corn exports, most of the reduction in exports to Japan and South Korea during November 2000 and March 2002 is due to Japan's increased purchases from South Africa, China's decision to continue to subsidize exports, increased competition from the large back-to-back crops in Argentina, and a record Brazilian crop. The net effect of StarLink on U.S. corn exports has been reduced somewhat as U.S. corn that otherwise would have been exported to Japan was diverted to other markets. During the 2000/01 marketing year, U.S. corn exports to Mexico, Canada, Egypt, and Indonesia were up by 2.8 million tons from a year earlier. The increases in U.S. corn exports to Mexico and Canada are probably not related to StarLink because they are not the traditional export markets for our competitors, such as Brazil. In addition, in the case of Mexico, the increase was partly attributed to an expanded market demand for feed grains and the fact that imported corn was priced lower than domestically produced corn. Changes in the corn-to-sorghum price relationship also favored corn imports from the United States. The increases in U.S. corn exports to Egypt (448,000 tons) and Indonesia (373,000 tons)--not major export markets for Brazil--are a mixture of the market diversion of available corn supply and the result of non-StarLink related factors. However, the gain in market diversion could be greater resulting from the diversion of U.S. corn to Brazil's non-traditional markets, despite temporary losses of the high-priced Japanese market.

What Lessons Have We Learned?

The StarLink incident illustrates the complexity of isolating crop varieties within the grain marketing system. Contrary to value-enhanced crops where producers follow an identity preservation (IP) program to segregate them from bulk commodities in exchange for price premiums, no market incentive mechanism exists for StarLink corn. Instead, the Aventis-USDA buyback program and legal arrangements with 17 State Attorneys General have provided a mechanism for channeling StarLink corn to feed or non-food industrial uses either through additional incentives or compensation coverage for additional testing and transportation expenses.

IP or segregation will become more crucial in the release of future biotech crops, especially biotech food grains (such as herbicide-tolerant wheat). The disruption to food producers and exporters that was caused by StarLink was mitigated significantly by channeling the commingled corn to feed use. However, in the case of the future release of herbicide-tolerant wheat, biotech-commingled wheat would not be as easy to channel to feed use because 1) it would not be practical (due to a large price disparity between food and feed uses), and 2) wheat feed use accounts for only a small fraction of total use. Having a workable IP system in place prior to the commercial release of this biotech crop is essential to differentiate segmented markets between biotech and nonbiotech varieties of wheat and to minimize market disruptions. This IP system clearly would have to provide producers and grain handlers sufficient economic incentives for its adoption through price premiums for nonbiotech wheat or price discounts for biotech-commingled wheat.

Zero tolerance, which applies to any use of StarLink corn in Japan and food use in South Korea as well as domestic food use, compounds the difficulties in segregation and IP. Segregation (even with record keeping) to meet zero tolerance is virtually impossible, given limitations of production and handling processes and the current testing technology. For example, based on USDA's GIPSA and the Food and Drug Administration sampling and testing recommendations, if StarLink was present in concentrations of 0.2 percent, there would be a 99-percent probability that a lot of corn would be rejected using the 2,400-kernel sample size (USDA, 2001_c). However, there still would be a 1-percent chance that it would be accepted. Thus, given meeting zero tolerance is impossible, securing approval of new biotech varieties in export markets and avoiding split regulatory decisions (for example, domestic feed- and not food-use approval) would be alternatives worth considering in order to avoid the difficulties. In fact, in March

2001, EPA announced it will no longer consider as a regulatory option a "split pesticide registration" for biotechnology products as occurred in the case of StarLink.

Institutional arrangements play a strategic role of preventing further commingling of StarLink corn and facilitating trade. The StarLink incident reaffirms the necessity of establishing a GIPSA reference laboratory to: 1) evaluate the performance of test kits, 2) develop sampling guidelines, and 3) accredit private laboratories. The U.S. and Japanese government testing protocols rest upon information about the consistent performance of test kits and sampling guidelines agreed by the two governments. Testing for the presence of StarLink corn in shipments to Japan is important to regain U.S. corn's food use market in Japan that was temporarily lost due to the StarLink incident. What is less clear is whether it is necessary for USDA to become involved in the certification of IP systems if large grain companies or private firms can adequately perform the task, as was the case in the certification of StarLink tests. Another option to be considered could be a quality-assurance program of USDA that provides the food industry with an independent, third-party verification process for facilitating the differentiation and segregation of biotech and nonbiotech crops.

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Endnotes

[1]Aventis CropScience is being sold to Bayer of Germany in a deal that was announced in October 2001 and is expected to be concluded in 2002.

[2]Commingling is defined as the combination or mixing of StarLink and cross-pollinated corn from the buffer zone (a 660-foot strip area between StarLink and other hybrid varieties required by a contract between Aventis and producers) with other varieties during harvest, storage, handling, and distribution of the grain. The effectiveness of the 660-foot strip area has been questioned by researchers.

[3]The likelihood of the cross-pollination between StarLink and conventional corn had been recognized by Aventis. In a company brochure entitled "2000 U.S. Edition," Aventis stated that "the use of StarLink

hybrids and any corn grown within 660 feet of StarLink hybrids is currently limited to domestic animal feed, industrial non-food, or seed production uses" (Harl *et al*.).

[4]In 1998, there were only about 10,000 acres of StarLink corn grown in the United States. In addition, most of the 1998 StarLink corn would have been used by end-users by September 2000.

[5]As of April 19, 2001, CCC had purchased 221,000 bushels of StarLink and commingled corn from producers. All the purchased corn was channeled to feed users, such as feedlots.

[6]The issue of losses resulting from commingled corn in the grain handling system was addressed later by Aventis' agreement to settle those claims on a case-by-case basis. The volume of marketed StarLink-commingled corn in 2000 depended on the percent of corn harvested by October 1 that year. For example, the percentage ranged from 27 percent to 37 percent in Iowa regions where food processors are located. In contrast, the percentage ranged from 54 percent to 88 percent in Nebraska. The 2000 corn crop was harvested earlier than normal due to warm spring weather.

[7] An elevator survey conducted by the U.S. Grains Council shows that about 22 percent of respondents, which handle about 50 percent of corn in the United States, have testing capabilities for genetic characteristics.

[8] This study does not estimate the potential volume of StarLink-commingled corn from the 1999 crop due to a lack of detailed data on StarLink acreage and marketing in that crop year.

[9] There are two different processes that convert corn into food products for human consumption. The wet-milling process tempers and soaks corn in steep water to soften and swell the kernels, which aids in the separation of starch, solubles, gluten, and hulls. The Cry9C protein is retained in gluten meal and feed, but not in starch, oil, or corn syrup, which are intended for human food consumption, as concluded in a

recent EPA white paper. In contrast, corn dry milling is basically a grinding procedure. Corn is degerminated by tempering it with steam heat or spraying it with warm water for oil extraction, and the remaining corn is ground and sieved into many fractions. The dry-milling process does not remove proteins from its products intended for human consumption. As a result, theCry9C protein can be detected in dry-mill products, including corn meals, corn flour, and corn grits. Still, wet millers tested inbound corn delivered to their facilities because they do not want to use StarLink-commingled corn in their operations which produce food products, such as starch and high fructose corn syrup. They are unwilling to take any chance in seeing StarLink-commingled corn wind up in their gluten feed or meal because the EU and Canada do not approve StarLink for any use.

[10] According to this agreement made in November 2000, USDA will test for StarLink in U.S. corn shipments destined for Japan, and shipments will take place if the corn is certified by USDA or private firms as StarLink-free.

[11] One metric ton equals 39.4 bushels of corn. The decrease in U.S. corn export sales to Japan remained at 1.2 million tons through late April, 2002.

[12] Japanese buyers pay a large price premium ($18.6/mt) for South African corn over U.S. corn in 2001, due in part, to its high starch content, substantially higher than the $1.8/mt premium for 2000. Preferences of Japanese buyers for StarLink-free corn have also contributed to the price differentials. For example, U.S. corn exported to Japan for starch use commanded a price premium of $9.8/mt over feed corn in 2001, up from $6.1/mt for 2000 and $1.9/mt for 1999. Similarly, Japanese buyers paid an average premium of $5.6/mt for Chinese corn over U.S. corn in 2001, up from an average discount of $0.9/mt for 2000. In contrast, South Korean buyers paid almost the same price to corn from different origins and for food and feed uses.

[13] On November 30, 2001, USDA announced a sale of 500,000 metric tons of U.S. corn to China. Meanwhile, trade sources were indicating that Chinese exporters have cancelled up to 1 million metric tons of corn export contracts, suggesting China's subsidizing its corn exports may be largely reduced.

Table 1. Input data

State	Greater-county area	Estimated 2000 harvest		Estimated total corn sold by Oct. 1, 2000	Total marketed StarLink by Oct. 1, 2000
		Acres	-----------------	-----Bushels-----	-----------------
AL	Morgan	41,700	3,546,700	1,853,151	9,165
IA	Clinton	639,800	93,984,580	2,283,825	28,200
	Lee	269,900	39,591,300	1,318,390	70,496
	Linn	1,114,800	161,010,920	3,912,565	324,435
	Mahaska	540,300	78,008,120	2,597,670	36,715
	Muscatine	511,700	75,038,000	1,823,423	84,790
IL	Cook	138,600	18,533,600	355,845	2,000
	Edgar	747,600	109,613,500	3,069,178	13,991
	Kankakee	1041,800	149,780,600	7,069,644	19,200
	Macon	1,225,600	207,079,500	10,933,798	14,800
	St. Clair	462,100	66,513,100	3,511,892	77,595
	Tazewell	1,150,700	179,715,900	9,489,000	18,200
	Vermilion	1,123,500	159,630,600	7,534,564	33,191
IN	Daviess	364,100	59,017,500	1,298,385	31,135
	Lake	369,900	51,954,700	1,143,003	84,705
KS	Atchison	283,200	36,506,500	2,496,909	198,429
	Wyandotte	32,600	3,446,700	243,935	12,128
KY	Christian	212,900	25,208,300	4,270,656	30,790
	Henderson	353,600	49,228,600	8,285,073	16,800
	Logan	185,700	19,697,200	3,398,753	52,250
MN	Lyon	825,100	118,549,600	1,849,374	86,716
MO	Buchanan	185,500	26,015,630	4,058,438	20,706
	Clay	215,300	30,535,670	4,763,565	91,016
NE	Butler	863,300	104,575,160	5,647,059	527,571
	Lancaster	878,000	97,718,800	5,276,815	312,431
	Saline	712,000	82,187,200	7,232,474	116,437
	Washington	375,900	49,398,240	2,667,505	105,216
TN	Madison	130,400	14,199,500	4,352,851	15,950
TX	Castro	236,800	40,300,320	12,412,499	169,126
VA	Hanover	36,300	5,703,300	751,667	7,020
WI	Columbia	623,900	85,461,400	538,407	23,600
Total		15,892,600	2,241,750,740	126,440,313	2,634,804

Table 2. Potential volume of StarLink-commingled corn in areas near wet and dry millers

State	Greater-county area	Number of wet millers	Number of dry millers	Potentially commingled corn in 2000	Commingling ratio
				Bushels	
AL	Morgan	1	1	1,843,986	201.2
IA	Clinton	1	0	2,255,625	80.0
	Lee	1	0	1,247,894	17.7
	Linn	3	1	3,588,130	11.1
	Mahaska	1	0	2,560,955	69.8
	Muscatine	1	0	1,738,633	20.5
IL	Cook	1	0	353,845	176.9
	Edgar	0	1	3,055,187	218.4
	Kankakee	0	1	7,050,444	367.2
	Macon	2	0	10,918,998	737.8
	St. Clair	0	1	3,434,297	44.3
	Tazewell	1	0	9,470,800	520.4
	Vermilion	0	1	7,501,373	226.0
IN	Daviess	1	0	1,267,250	40.7
	Lake	1	0	1,058,298	12.5
KS	Atchison	0	1	2,298,480	11.6
	Wyandotte	0	1	231,807	19.1
KY	Christian	0	2	4,239,866	137.7
	Henderson	0	1	8,268,273	492.2
	Logan	0	1	3,346,503	64.0
MN	Lyon	1	0	1,762,658	20.3
MO	Buchanan	0	1	4,037,732	195.0
	Clay	1	0	4,672,549	51.3
NE	Butler	1	0	5,119,488	9.7
	Lancaster	0	1	4,964,384	15.9
	Saline	0	1	7,116,037	61.1
	Washington	1	0	2,562,289	24.4
TN	Madison	0	1	4,336,901	271.9
TX	Castro	1	0	12,243,373	72.4
VA	Hanover	0	1	744,647	106.1
WI	Columbia	0	1	514,807	21.8
Total		19	18	123,805,509	47.0

Table 3. Comparisons of corn imports into Japan and South Korea for starch manufacturing or non-feed use during November 2000 and March 2002 and year-and-half earlier levels by source of supply

Source of supply	Corn imports into Japan for starch use			Corn imports into South Korea for non-feed use		
	Nov.-Mar. 1999/2001	Nov.-Mar. 2000/02	change	Nov.-Mar. 1999/2001	Nov.-Mar. 2000/02	change
	-----1,000 metric tons-----		%	-----1,000 metric tons-----		%
United States	4639.5	2783.6	-40.0	2171.1	1133.9	-47.8
South Africa	287.9	687.8	138.9	0.0	46.6	n.a.
China	80.9	270.0	233.7	583.7	306.2	-47.5
Argentina	0.0	241.7	n.a.	46.9	248.9	430.7
Brazil	0.0	527.8	n.a.	0.0	1041.3	n.a.
All countries	5008.3	4510.9	-9.9	2858.0*	2804.6*	4.5

Source: *World Trade Atlas* Trade Information System.
*Includes imports from Australia.

Figure 1. Accumulated exports of U.S. corn to Japan during the weeks from 9/7/00 to 8/30/01

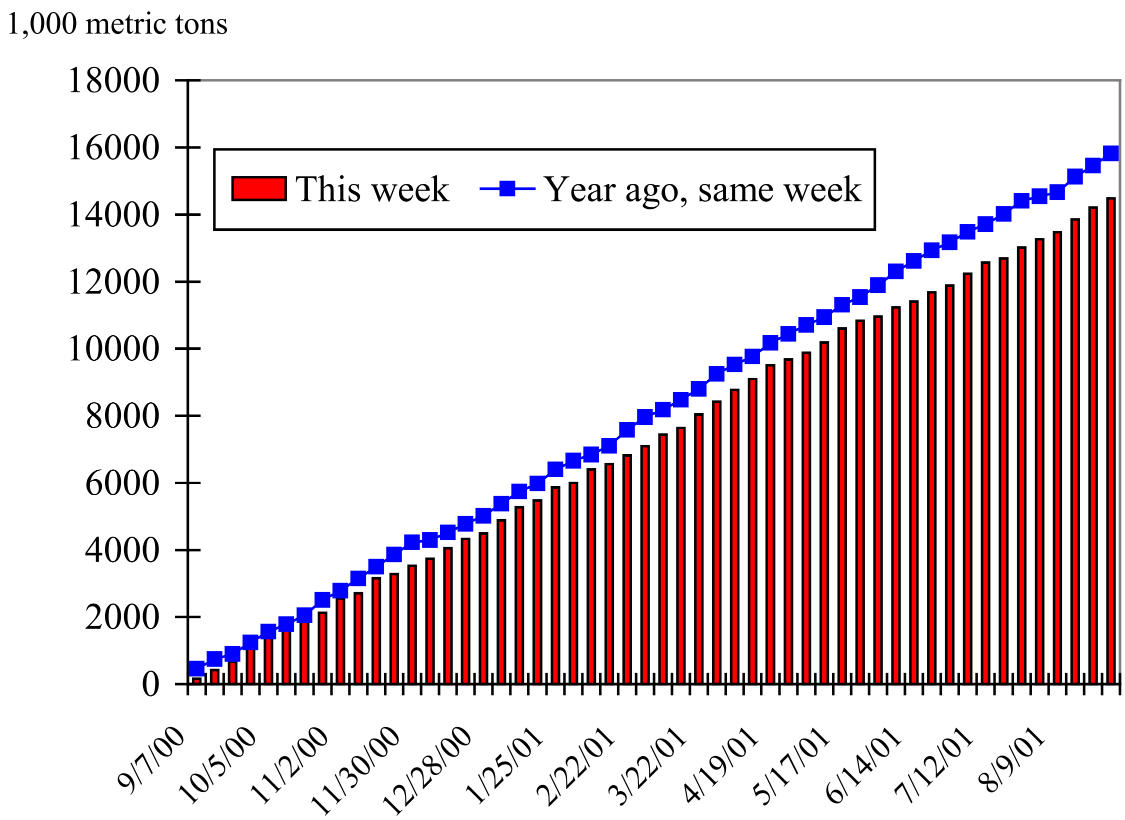

Figure 2. Outstanding export sales of U.S. corn to Japan during the weeks from 9/7/00 to 8/30/01