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 2000/01 marketing year as a result of inadvertent commingling. The potential, upper-bound volume of marketed StarLink-commingled corn from the 2000 crop located near wet and dry millers prior to October 1, 2000, is estimated at 124 million bushels. The percentage of corn shipments that tested positive mostly ranged from 5 to 10%, varying by mode of transportation. Price differentials between StarLink-commingled and StarLink-free corn commonly ranged between 7 and 12 cents per bushel during the early stage of the incident. These differentials eroded quickly due largely to Aventis' compensation of additional transportation costs when StarLink-commingled shipments had to be rerouted to approved uses. While StarLink had a negative impact on U.S. corn exports, most of the reductions in exports to Japan and South Korea during the period from November 2000 through March 2002 were due to increased competition from rival exporters. [EconLit citations: Q130, Q170]. © 2003 Wiley Periodicals, Inc.

1. INTRODUCTION

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

[1]Aventis CropScience was sold to Bayer, a company based in Germany, in a deal that was announced in October 2001, and completed in June 2002.

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StarLink was approved for feed and nonfood 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. Despite this restriction, StarLink was discovered in the processed food chain. On September 18, 2000, a news headline reported that some Taco Bell taco shells sold in retail stores contained the Cry9C protein after a testing lab reported the presence of StarLink DNA in the product. This discovery had repercussions throughout the grain handling and processing sectors as well as in global grain trade during the 2000/01 marketing year.

The discovery of the Cry9C protein in processed foods led to a series of product recalls. Kraft Foods, Inc., the company that produces Taco Bell taco shells, removed the product from store shelves after the firm confirmed the initial test results. In total, nearly 300 food products, including more than 70 types of corn chips, more than 80 kinds of taco shells, and almost 100 food products served in restaurants, were taken off the market. The recalls did not necessarily reflect that StarLink had been found in all of those products, but was a precaution taken by the manufacturers of the items. A few months later, StarLink was found in more corn-based 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) some of the corn grown on the buffer zone was probably crosspollinated with StarLink corn,[3] (2) a portion of StarLink corn (including that grown in the buffer zone) entered the marketplace prior to an effort to contain StarLink-commingled corn, and (3) some elevators did not know that they had received 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 offered producers a 25-cents-per-bushel premium above the posted-county price for October 2, 2000, to ensure that StarLink corn was 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

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

[3]The likelihood of crosspollination between StarLink and conventional corn was recognized by Aventis. In a company brochure entitled "StarLink: The Next Generation of Bt Corn," Aventis stated that "the use of StarLink hybrids and any corn grown within 660 feet of StarLink hybrids . . . [was] limited to domestic animal feed, industrial nonfood, or seed production uses" (Harl, Ginder, Hurburgh, & Moline, 2001).

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

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

already been delivered to local elevators.[6] In November 2000, the U.S. and Japanese governments reached an agreement that establishes testing protocols, which are implemented through sales contracts, for detecting StarLink in U.S. food corn shipments to Japan. Then, in January 2001, Aventis agreed with 17 State (including Iowa) Attorneys General to expand compensation coverage to grain elevators (Harl, Ginder, Hurburgh, & Moline, 2001).

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, USDA agreed in March 2001 to purchase seed containing Cry9C from seed companies that were not associated with Aventis.

Although concern over the StarLink incident has subsided, the need for having an effective segregation system in place to prevent potential commingling with conventional varieties remains an issue of interest for future releases of biotech crops. The main purpose of this article is to assess the impacts of the StarLink incident on the U.S. corn market and global corn trade. Specifically, the objectives are to: (1) examine the disruptions caused by the incident in the domestic and export corn markets, (2) 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) estimate the impacts of StarLink on global corn trade and U.S. corn exports.

2. 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. Market disruptions were mitigated by directly channeling the commingled corn to feed use, which accounts for about 60% of U.S. corn disappearance (U.S. Department of Agriculture [USDA], 2000a). Alternatively, commingled corn was channeled to certain nonfood 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% of U.S. corn disappearance.

In response to the potential commingling of StarLink with other corn, local elevators owned by large grain companies (i.e., those that 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 also conducting StarLink tests because of compensation provided by Aventis.[7]

[6]The issue of losses resulting from commingled corn in the grain handling system was later addressed by Aventis' agreement to settle those claims on a case-by-case basis. The volume of marketed StarLink-commingled corn from the 2000 crop depended on the percent of corn harvested by October 1 of that year, which varied by production location. For example, the percentage ranged from 27 to 37% within Iowa. In contrast, the percentage ranged from 54 to 88% in Nebraska. In general, 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% of respondents, which handle roughly 50% of corn in the United States, have testing capabilities for detecting genetic characteristics.

Food processors (including corn dry and wet millers) are testing inbound corn delivered to their facilities.[8] 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 (Environmental Protection Agency [EPA], 2001a). Wet millers conduct the test because of concerns about using StarLink-commingled corn in their wet milling operations.[9] 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.

The lateral flow strip test, a protein-based method, is the most frequently used test at elevators and processing facilities to determine whether the Cry9C protein is present in a sample. The test takes about 10 minutes to perform and indicates the presence or absence of the StarLink-specific protein with a "yes" or "no" response. USDA's Grain Inspection, Packers, and Stockyards Administration (GIPSA) has evaluated the performance of some test kits and verified that they are capable of detecting the presence of Cry9C protein. Presently, the detection sensitivity reaches 0.125% (1 StarLink kernel in 800) for most test kits. For two highly sensitive micro-titer well test kits, which are an ELISA testing method but take considerably longer than 10 minutes, the sensitivity is even higher at 0.01% (1 StarLink kernel in 10,000). These tests cost around $4 each.[10]

Elevators face the problem of conflicting StarLink test results, in part, because different test samples taken from the same lot of corn may yield different results. A common practice (e.g., as specified under the Japan food corn testing protocol) is to test three 800-kernel subsamples. If all three tests (2,400 kernels) are negative, there is a 99% probability that the sample does not contain more than 0.2% of StarLink corn (USDA, 2001b).

Some elevators even use a more sophisticated and more sensitive DNA-based technique called the polymerase chain reaction (PCR) test, which can detect specific foreign genetic material inserted into corn's DNA. The cost of the test ranges from $200 to $450 and takes 2–10 days to obtain the results, which disrupts the rapid turnover of grain elevator operations. However, the 10-day upper limit is uncommon. Although some river elevators use this test method, only one test is required per barge shipment.

When corn shipments are rejected by processors or for export, arrangements must be made to alter grain flow patterns by hauling the grain away from processing facilities or export ports to feed or nonfood industrial users. Rerouted shipments impose extra transportation costs on grain elevators. For example, higher rates are sometimes associated with breaking up unit trains into smaller, multicar units bound for alternative destinations. Compensation by Aventis for any extra transportation costs is possible if the ex-

[8]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. 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. The remaining corn is ground and sieved into many fractions.

[9]Wet millers test inbound corn delivered to their facilities because they do not want to use StarLink-commingled corn in their operations, which produce food products for human consumption. They are unwilling to take any chance in seeing StarLink-commingled corn end up in their gluten feed or meal because the European Union and Canada do not approve StarLink for any use.

[10]The cheapest test kits now cost less than $4 each, and the price could decline as more test kits enter the marketplace. Some elevators and processors did not incur testing costs because Aventis provided them with test kits free of charge.

penses are documented (Harl, Ginder, Hurburgh, & Moline, 2001). In most cases, the rerouting of rejected grain involves shipment to destinations not far from the originally intended destination. Demurrage—a charge for detaining a truck or freight car—because of the rerouting of 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 that tested positive mostly ranged from 5 to 10% during the 2000/01 marketing year. However, most corn shipments testing positive for StarLink exhibited relatively low concentrations. Also, this percentage of corn shipments varied by mode of transportation. In the case of truck shipments, the percentage of shipments that tested positive averaged about 5%. In contrast, the percentage was lower for barge shipments because they are primarily destined for export markets, and many river elevators conducted StarLink tests to avoid shipments of commingled corn to those markets. The percentage of rail shipments that tested positive, on other hand, was higher than that for truck shipments. By November 2001, most U.S. corn shipments were found to be virtually StarLink free—only 1% or less 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 level. 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% or lower, transportation costs could potentially double (Lin, Chambers, Harwood, 2000). The cost of segregating nonbiotech corn was recently estimated to be around 22 cents per bushel (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% for the Japanese market (Lin, Chambers, Harwood, 2000). A sale of segregated nonbiotech corn to South Korea in spring 2001 suggests lower segregation costs of 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 were 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 (about 4 to 6% 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 (in addition to any extra transportation costs) is possible if they are documented (Harl, Ginder, Hurburgh, & Moline, 2001). Price discounts for StarLink corn were reportedly widespread, especially in the southeastern poultry and export markets. However, trade volume for StarLink-free corn in the domestic market was very thin, especially in those areas commanding higher premiums.

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, the agreement made by the U.S. and Japanese governments in November 2000 to establish testing protocols for food corn to resolve related trade issues, and the Aventis–17 State Attorneys General agreement reached in January 2001 to extend compensation coverage to grain elevators. Third, premiums for StarLink-free corn were also reduced as buyers were able to source StarLink-free corn.[11] Finally, many grain companies did not discount StarLink corn prices paid to producers because Aventis assumed the cost of diverting the grain to approved uses. In Spring 2001, the price differentials were small or nonexistent. At present, there are virtually no price differentials.

3. 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.[12] The assumptions of the scenario analysis and the data sources will be discussed first, and then the results of the estimation will be presented. The results of this scenario analysis are one of many possible outcomes, which can vary depending on the assumptions and procedures used. The findings of 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.

3.1 Scenario Development

The Aventis–USDA buyback program 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 corn wet- and dry-milling facilities.

To determine the potential volume of StarLink-commingled corn from the 2000 crop in areas near wet- and dry-milling facilities, this study uses county-level production and marketing data to identify local "hot spots." Hot spots are defined as areas where large

[11]Although buyers were able to source StarLink-free corn, such actions do not necessarily imply that additional costs were not incurred. Reported prices are at best an incomplete indicator of the actual market impacts of StarLink in food milling and manufacturing. Moreover, the prices do not fully capture the externalities associated with the incident. Grain handlers and food processors may have been forced to bear extra uncompensated search and transportation costs to originate StarLink-free corn. Because StarLink production was localized, some elevators and food processors located in areas with large volumes of commingled corn have had to source StarLink-free corn at higher costs from relatively far distances to avoid procuring commingled corn. Hence, the reported prices paid to elevators or producers may not have represented the true landed prices faced by food processors or elevators. Similarly, hidden costs may have applied to some elevators. There were cases where buyers refused to accept contracted grain (and even offered premiums to producers) to keep their stocks StarLink-free while they looked for alternative sources. In other situations, some elevators chose not to purchase grain from farms where any Garst (a major StarLink seed distributor) hybrid was planted. Those losses to producers were not fully covered by Aventis because they had neither planted StarLink nor were affected by crosspollination. Therefore, due to additional hidden costs, the effective prices associated with StarLink-free corn were higher than what were implied by the reported market prices.

[12]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.

StarLink acres were planted or significant amounts of commingled corn were marketed near wet- and dry-milling facilities. Although high concentrations of StarLink acreage may have contributed to significant commingling, the mixing of StarLink with other varieties may have occurred in areas with large corn production even though StarLink acreage was relatively small. The potential for commingling could have been greater in certain locations where the proportion of the corn crop harvested by October 1, 2000, was higher than in other areas. For example, because states in the South typically harvest their crop in August, corn (StarLink and other varieties) harvested in that region was more likely to have entered the grain handling system before the buyback program began.

3.2 Data and Methodology

The locations of corn wet- and dry-milling facilities were obtained from the Corn Refiners Association (personal communication, October 2000) and the *Grain & Milling Annual 1999* (Milling & Baking News/World Grain, 1998), respectively. Based on the geographic information, 2000 county-level data on harvested corn acreage and yields were gathered from the USDA's National Agricultural Statistics Service (USDA, 2001a). 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 and/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. Multicounty 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, 2001a) 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, 2000b). The volume of marketed StarLink corn by county (including the corn grown in the buffer zone) was obtained from Aventis' survey of StarLink producers (Aventis, 2000). The acreage, production, and marketing data employed in this analysis are provided in Table 1.

For illustrative purposes, the greater Linn County area in Iowa is presented to show how the volumes of 2000-crop corn (3.9 million bushels) and StarLink (324,400 bushels) sold by October 1, 2000, were estimated for a given greater-county area. The Iowa counties that surround Linn County are Buchanan, Delaware, Benton, Jones, Cedar, Johnson, and Iowa. 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%. Then, that value was multiplied by the estimated share of corn sold up to that date (9%), based on 1999/00 marketing year sales data. The 324,400 bushels of marketed StarLink and buffer-zone corn were estimated by Aventis.

The StarLink corn marketed prior to October 1, 2000, in a greater-county area was assumed to be commingled with other corn from the area sold before that date. The volume of potentially commingled conventional corn (excluding StarLink and buffer-zone

TABLE 1. Input Data on Estimated Total Corn and StarLink Corn Marketed by October 1, 2000.

			Bushels		
State	Greater-County Area	2000 Corn Harvested Acres	Estimated 2000 Corn Production	Estimated Total Corn Sold by Oct. 1, 2000	Total Marketed StarLink by Oct. 1, 2000
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	1,041,800	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

Sources: Agricultural Statistics Data Base, U.S. Department of Agriculture, National Agricultural Statistics Service (2001); *Agricultural Prices: 1999 Summary*, U.S. Department of Agriculture, National Agricultural Statistics Service (2000); Aventis CropScience (2000).

corn) in a given area was calculated as the difference between the total volume of marketed corn and the volume of StarLink corn sold as of 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

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 (Bushels)	Commingling Ratio
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

Sources: Personal communication, Corn Refiners Association, October 2000; *Grain & Milling Annual 1999*, Milling & Baking News/World Grain (1998).

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.

3.3 Results

This section presents 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 identifies 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 spots where large volumes of potentially commingled corn existed near processing facilities 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% of the 2000 crop. The actual volume of commingled corn may differ from the potential volume estimated in this study.

In Iowa, where 40% of the StarLink corn was grown (Harl, Ginder, Hurburgh, & Moline, 2001) 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% 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, 2000). 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 just outside these counties. Furthermore, the scenario analysis does not account for the possibility of intrastate and interstate corn shipments because of a lack of information about current grain flow patterns. These shipments could have compounded the risk of commingling StarLink corn with other varieties in the grain handling system. This study also does not take into account varying handling practices, which may affect the potential risk of commingling. For example, many river elevators can directly unload corn onto vessels, which would lower 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 have been 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, 2001). Most of the 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.

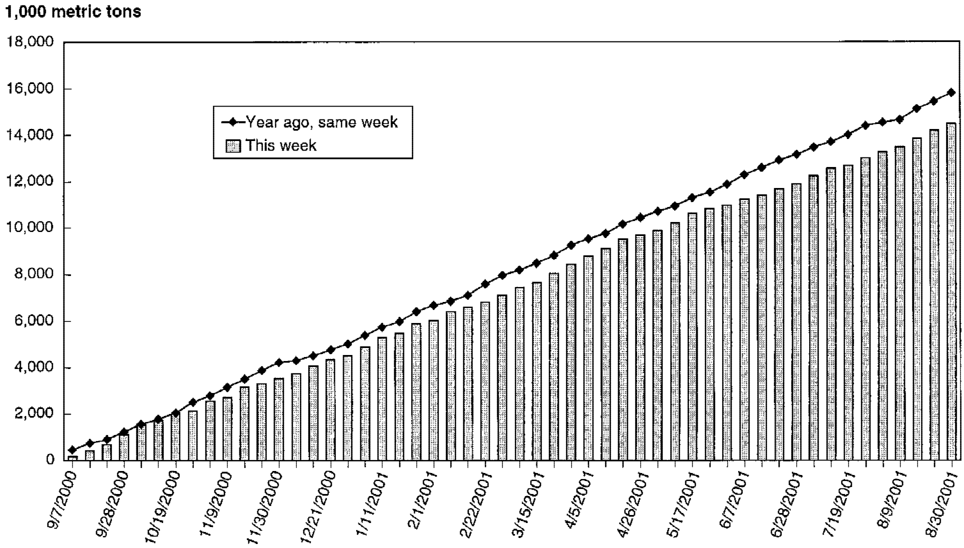

Figure 1 Accumulated exports of U.S. corn to Japan during the weeks ending from 9/7/2000 to 8/30/2001.

Source: *U.S. Export Sales*, U.S. Department of Agriculture, Foreign Agricultural Service (2000 & 2001).

4. EFFECTS OF STARLINK ON 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 in Japan and only food use in South Korea) and discrepancies over testing protocols, at times, disrupted corn shipments destined for those markets during the 2000/01 marketing year.

4.1 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 the 2000/01 marketing year. 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 that would be implemented through sales contracts (Fig. 1).[13]

The disruption continued throughout the next few months as discrepancies over StarLink testing results arose. For example, U.S. corn exports to Japan from September 1 to the week ending December 28, 2000, were down about 11% from a year earlier (USDA, 2000 & 2001). This decline narrowed to about 7% by mid-April 2001 and then widened to 10% by mid-July 2001. Outstanding sales of U.S. corn to Japan at the end of calendar year 2000 were down about 21% from a year earlier. The gap widened to 44% by mid-April but dis-

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

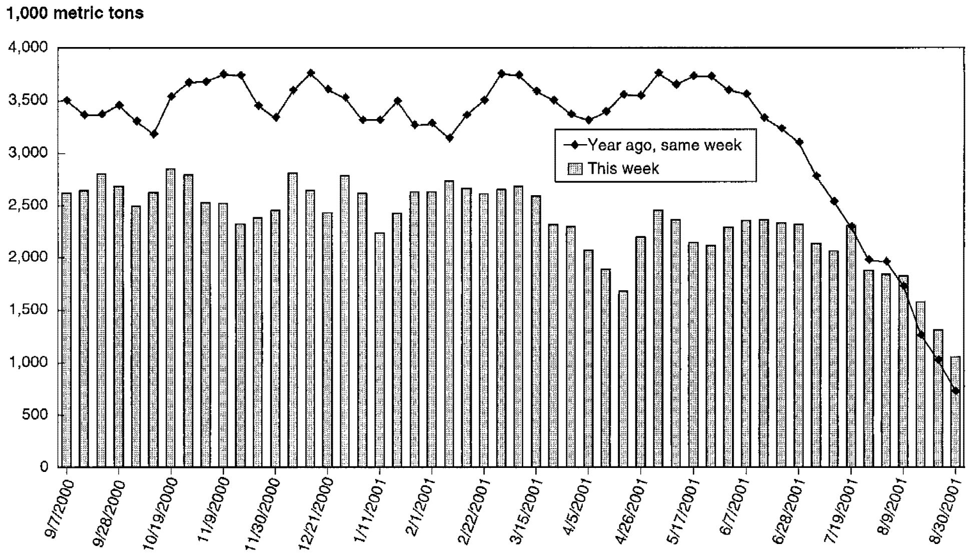

Figure 2 Outstanding export sales of U.S. corn to Japan during the weeks ending from 9/7/2000 to 8/30/2001.

Source: *U.S. Export Sales*, U.S. Department of Agriculture, Foreign Agricultural Service (2000 & 2001).

appeared by mid-July 2001 (Fig. 2). As of August 30, 2001 (the end of the U.S. 2000/01 marketing year), accumulated U.S. corn exports and outstanding sales to Japan together were down about 1 million metric tons from a year earlier, a decline of 6%.[14]

U.S. corn exports to South Korea from September 1 to the end of 2000 were down even more than those to Japan from a year earlier, falling 55%. The decline became less severe in early 2001 and was down to just over 30% by mid-April 2001. For the entire 2000/01 marketing year, U.S. corn exports to South Korea exceeded those in the previous year by 0.5%. As of August 30, 2001, accumulated U.S. corn exports and outstanding sales to South Korea together were up 3% from a year earlier.

The StarLink incident is one of several factors that contributed to the rearrangement of trade flow patterns in the world corn market. Although the incident appears to have been an important factor, a more significant factor in the decrease of U.S. exports was greater 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 purchase corn from Brazil, such as the Middle East, Spain (not a U.S. export market), South Africa, and the Far East. A record Brazillian corn crop in the 2000/01 marketing year made its corn more price competitive, tempering the diversion of U.S. corn exports despite greater availability. The gain in market diversion could have been greater as a result of exporting U.S. corn not sold to Japan and Korea for food use to markets that did not traditionally purchase corn from Brazil.

[14]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.

4.2 Trade Effects

The markets most affected by Starlink were those for nonfeed corn in Japan and South Korea. Import statistics from those countries show a sizeable decline in the U.S. share of corn imports that were purchased for nonfeed use. From November 2000 through October 2001, Japan's imports of U.S. corn for starch manufacturing were down 37% from a year earlier, a decrease of 1.3 million tons. The decrease continued into March 2002, resulting in a drop of 1.8 million tons during the period of November 2000 through March 2002 when compared with the similar period a year earlier (Table 3). As a result, the U.S. share of corn imports into Japan for starch use declined from 93% (November 1999 through March 2001) to 62% (November 2000 through March 2002) after the StarLink incident occurred. Meanwhile, imports for starch from non-U.S. origins, including South Africa, China, Argentina, and Brazil, increased from less than 0.1 million tons (November 1999 through March 2001) to 1.7–1.9 million tons (November 2000 through March 2002), depending on whether the use category "not elsewhere specified" is included.

Similarly, South Korea's imports of U.S. corn for food manufacturing (mostly starch) during the same year-and-a-half period after the incident were down 53% from the comparable period before the incident, a decline of about 1.2 million tons (Table 3). The U.S. share of corn imports by South Korea for nonfeed uses declined from 76 to 36% during the same periods. Virtually all of the decline was offset by an increase in imports from non-U.S. origins; these imports were more than double their levels a year earlier. As previously indicated, 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 during the first half of 2000/01. However, as of April 25, 2002, U.S. corn exports to South Korea over the previous year and a half (September 2000 through April 2002) declined by about 1.0 million tons, a drop of nearly 20%, compared with the level a year earlier (September 1999 through April 2001). The decrease reflects the fact that South Korea increased its nonfeed corn sourcing from Brazil at the expense of the United States over the 6 months preceding April 2002.

Competing exporters' trade data from November 2000 to March 2002 give similar results (Table 3). During that period, Japanese buyers purchased additional corn for food

TABLE 3. Comparison of Corn Imports into Japan and South Korea for Starch Manufacturing or Nonfeed Use during November 2000 to March 2002 and Levels a Year Earlier by Supply Source

	Corn Imports into Japan for Starch Use			Corn Imports into South Korea for Nonfeed Use		
Source of supply	Nov. 1999–Mar. 2001	Nov. 2000–Mar. 2002	Change %	Nov. 1999–Mar. 2001	Nov. 2000–Mar. 2002	Change %
	1,000 Metric Tons			1,000 Metric Tons		
United States	4,639.5	2,864.2	−38.3	2,262.7	1,066.0	−52.9
South Africa	287.9	698.0	142.5	44.3	44.3	0
China	81.0	272.8	236.8	618.5	271.4	−56.1
Argentina	0.0	241.7	n.a.	46.9	265.9	466.5
Brazil	0.0	534.7	n.a.	0.0	1,329.9	n.a.
All countries	5,008.4	4,611.4	−7.9	2,980.2[a]	2,999.6[a]	0.7

[a]Includes imports from Australia.

Source: World Trade Atlas, Global Trade Information Services, Inc. (Internet Version 4.3e).

processing from South Africa—about 700,000 tons—mostly from the large crop harvested in 2000.[15] 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 subsidizing exports (a decision not related to StarLink) during 2000/01. However, China substantially reduced its corn exports to Japan and South Korea during the first quarter of 2002 but raised its corn exports during the second quarter. In addition, Japanese buyers purchased additional corn for starch manufacturing during November 2000 through March 2002 from Brazil (535,000 tons) and Argentina (242,000 tons).

Although StarLink 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 was due to Japan's increased purchases from South Africa, China's export subsidies, increased competition from large back-to-back crops in Argentina, and a record Brazilian crop. The net effect of StarLink on U.S. corn exports was 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 2.8 million tons from a year earlier (USDA, 2000 & 2001). 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 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—were due to a mixture of market diversion of available corn and non-StarLink related factors. Hence, the gain in market diversion could have been greater because of diversion of U.S. corn to Brazil's nontraditional markets despite temporary losses associated with the high-priced Japanese market.

5. 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 existed for segregating StarLink corn. Instead, the Aventis-USDA buyback program and legal arrangements with 17 State Attorneys General provided a mechanism for channeling StarLink corn to feed or nonfood industrial uses through monetary incentives and compensation coverage for additional testing and transportation expenses.

IP or segregation will become crucial in the release of future biotech crops, especially biotech food grains (such as herbicide-tolerant wheat). The disruptions to food processors and exporters caused by StarLink were mitigated significantly by channeling the commingled corn primarily to feed use. However, in the case of the potential future release of

[15] Japanese buyers paid a large price premium ($18.60/metric ton) for South African corn over U.S. corn in 2001 due, in part, to its high starch content. This premium was substantially higher than the $1.80/metric ton premium paid in 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 $9.80/metric ton over feed corn in 2001, up from $6.10/metric ton in 2000 and $1.90/metric ton in 1999. Similarly, Japanese buyers paid an average premium of $5.60/metric ton for Chinese corn over U.S. corn in 2001, up from an average discount of $0.90/metric ton in 2000. In contrast, South Korean buyers paid almost the same price for corn imported from different origins.

herbicide-tolerant wheat, biotech-commingled wheat would not be easily channeled to feed use because (1) large price disparities between food and feed uses makes such activities impractical, 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 would minimize the potential price discounts against commingled wheat that would be levied by domestic flour millers and food manufacturers as well as foreign buyers. Clearly, this IP system would have to provide sufficient economic incentives—price premiums for nonbiotech wheat or price discounts for biotech-commingled wheat—to induce producers to adopt herbicide-tolerant wheat and grain handlers to segregate biotech wheat from conventional varieties.

Zero tolerance, which applies to any use of StarLink corn in Japan as well as food use in South Korea and the United States, compounds the difficulties in segregation and IP. Segregation (even with record keeping) to meet zero tolerance is virtually impossible, given the limitations of production and handling processes and current testing technology. For example, based on GIPSA's and the Food and Drug Administration's sampling and testing recommendations, if StarLink was present in concentrations of 0.2% or higher, there would be a 99% probability that a lot of corn would be rejected using a 2,400-kernel sample (USDA, 2001c). However, there still would be a 1% chance that it would be accepted. Given that meeting zero tolerance is nearly impossible, securing approval of new biotech varieties in export markets and avoiding split regulatory decisions (e.g., approval for domestic feed use but not for food use) would be alternatives worth considering to avoid these difficulties. In fact, in March 2001, EPA announced it will no longer consider "split pesticide registration" (as occurred in the case of StarLink) a regulatory option for biotech products (EPA, 2001b).

Institutional arrangements play a strategic role in preventing further commingling of StarLink and facilitating trade. The U.S. and Japanese governments' testing protocols, which were based on information about the consistent performance of test kits and sampling guidelines agreed upon by the two countries, helped to minimize market disruptions. The GIPSA reference laboratory project, which evaluates the performance of test kits and develops sampling guidelines, aided the implementation of the testing protocols. Testing for the presence of StarLink in corn shipments to Japan is important for regaining U.S. share of the corn 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 testing. Another option that warrants consideration is a USDA quality-assurance program that provides the food industry with an independent, third-party process verification for facilitating the differentiation and segregation of biotech and nonbiotech crops.

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