Agribusiness & Applied Economics Report No. 515 May 2003

Potential Impacts of GM Wheat on United States and Northern Plains Wheat Trade

Richard D. Taylor
Eric A. DeVuyst
Won W. Koo

Center for Agricultural Policy and Trade Studies
Department of Agribusiness and Applied Economics
North Dakota State University
Fargo, North Dakota 58105-5636

ACKNOWLEDGMENTS

The authors extend appreciation to Mr. Bruce Dahl, Mr. Jeremy Mattson, and Mr. Andrew Swenson for their constructive comments and suggestions. Special thanks go to Ms. Beth Ambrosio, who helped to prepare the manuscript.

The research was conducted under the U.S. agricultural policy and trade research program funded by the North Dakota Farmers Union and by the U.S. Department of the Treasury/U.S. Customs Service (Grant No. TC-01-002G, ND1301).

We would be happy to provide a single copy of this publication free of charge. You can address your inquiry to: Beth Ambrosio, Department of Agribusiness and Applied Economics, North Dakota State University, P.O. Box 5636, Fargo, ND, 58105-5636, Ph. 701-231-7334, Fax 701-231-7400, e-mail beth.ambrosio@ndsu.nodak.edu . This publication is also available electronically at this web site: http://agecon.lib.umn.edu/.

Information on other titles in this series may be obtained from: Department of Agribusiness and Applied Economics, North Dakota State University, P.O. Box 5636, Fargo, ND 58105. Telephone: 701-231-7441, Fax: 701-231-7400, or e-mail: cjensen@ndsuext.nodak.edu.

TABLE OF CONTENTS

LIST OF TABLES

Abstract

The potential introduction of genetically modified (GM) wheat has both supporters and opponents waging battle in the popular press and scholarly research. Supporters highlight the benefits to producers, while the opponents highlight the unknown safety factors for consumers. The topic is very important to the United States, as a large portion of the wheat production is exported overseas. Consumer groups in some countries are resisting GM wheat.

This study utilizes a spatial equilibrium model to evaluate the trade impacts associated with GM wheat introduction along with several assumed post-GM adoption scenarios. Wheat is converted into protein equivalents to allow for substitution between wheat classes.

The importance of the U.S. handling/transportation system is highlighted in the ability of the system to develop an affordable and effective segregation system for GM wheat. Producers who do not produce GM wheat would face externalities associated with GM wheat contamination of non-GM wheat.

Keywords: genetically modified wheat, spatial equilibrium model, trade flows, protein equivalents, externalities

Highlights

The potential introduction of Genetically Modified (GM) wheat has been in the news for several years. Because of consumer concern over the safety of the product, acceptance in overseas markets is questionable. This is an especially important issue in agricultural trade because more than 50% of the spring wheat produced in the United States is exported and about 47% of current spring wheat exports are to countries which have stated that they will not accept GM wheat.

Most previous studies assume that the handling/transportation system will not be able to develop an affordable and effective system to segregate wheat, but this study assumes that the handling/transportation system may be able to segregate GM wheat. A scenario is also run under the assumption that the handling/transportation system will not be able to segregate GM wheat.

Under most scenarios, if segregation is successful, there is little change in export volume. When GM wheat is produced, export volumes increase slightly for North Dakota and other spring wheat producing regions. Winter wheat and Canadian producing regions export slightly less wheat when GM wheat is produced in the United States.

The scenarios which, if segregation is successful, allow Canadian producers to produce GM wheat are similar to the scenarios for U.S. production. Canadian exports of wheat increase slightly under the scenarios. The winter wheat region in the United States loses exports.

Under an equilibrium condition, the price of GM wheat should fall by the production cost savings less the segregation fee and the amount of default on the export loans. In most cases, GM wheat is priced about $2.10 to $2.15 per metric ton less than non-GM wheat. Producer welfare increases by $2.50 per metric ton, assuming that successful segregation is achieved for $2.33 per metric ton, that there is a $2 cost advantage of raising GM wheat, and that 76% of North Dakota spring wheat and 100% of other U.S. spring wheat production is GM. If yields of GM wheat are increased by 10%, producer welfare increases by $19.28 per metric ton for GM wheat regions. If GM wheat is 30% of spring wheat production, there is little or no gain in producer welfare, again, assuming segregation is successful.

When segregation is unsuccessful, producer welfare in the United States drops by $10.56 per metric ton, or about $0.29 per bushel for spring wheat and $0.30 per bushel for winter wheat. Producer welfare for Canadian producers increases $16.53 per metric ton, or about $0.45 per bushel, because Canada exports non-GM wheat to Japan, S. Korea, and the EU. The study did not consider the impact on producers of durum wheat if segregation is unsuccessful.

When GM wheat is introduced, Japan, the EU, and S. Korea import wheat from either Canada or segregated non-GM winter wheat from regions of the United States. If the U.S. marketing/transportation system is unable to develop an affordable and dependable segregation system, these countries import wheat from Canada and other non-GM wheat producing countries.

Potential Impacts of GM Wheat on United States and Northern Plains Wheat Trade

Richard D. Taylor, Eric A. DeVuyst, and Won W. Koo*

INTRODUCTION

The potential introduction of Genetically Modified (GM) wheat has been in the news for several years. This publicity is in contrast to the attention given to the introduction of other GM crops, such as soybeans and corn, which were introduced several years ago. Currently, Monsanto is expected to introduce a glyphosate-tolerant spring wheat variety in the next two to five years. Because of consumer concern over the safety of the product, acceptance in overseas markets is questionable. Foreign market acceptance is an especially important issue in agricultural trade because more than 50% of the spring wheat produced in the United States is exported and about 47% of current spring wheat exports are to countries which have stated that they will not accept GM wheat. These countries include Japan, the European Union (EU), and S. Korea. Many other countries have not made definite decisions concerning GM wheat. Consumer response to GM foods is influenced by perception of benefits and risks of GM food and by confidence or trust in government regulatory systems charged with risk assessment and management (Wilson et al.). Science has not shown that GM foods are unsafe, but at the same time, has not convinced the consuming public in some countries that GM foods are safe. The discussion involving the safety and feasibility of GM foods has left the area of economics and science and has entered the arena of political and emotional debate.

The current genetic trait to be introduced into the wheat variety is resistance to glyphosate herbicide. Glyphosate-tolerant soybeans have gained popularity with producers for several reasons. With glyphosate-tolerent crops, timing of the application of the glyphosate herbicide is not critical and the producer has more time to spray for post-emergent weeds. The fields are generally cleaner for the next year's crop and there is little carry-over, which allows for a flexible crop rotation. The herbicide cost for glyphosate-tolerant crops is generally less than conventional herbicides. Finally, there is little herbicide damage to the crop, thereby increasing potential yields. Currently in the United States, 9% of the corn and 75% of soybean plantings are glyphosate-tolerant (USDA). The main drawbacks for glyphosate-tolerant crops are the potential development of glyphosate-resistant weed varieties and the difficulty of controlling the volunteer crop the following year. Current benefits of GM crops are directed toward producers (Janzen et al.), but future strains of GM crops may include qualities which consumers desire.

Wheat is unique when compared to either corn or soybeans. Both corn and soybeans are generally removed from human consumption by many steps and processes. Corn is mainly fed to livestock, and soybeans are processed into soybean oil and meal before consumption. By

---

*Richard Taylor is a Research Scientist, and Won W. Koo is Professor and Director, for the Center for Agricultural Policy and Trade Studies, NDSU. Eric DeVuyst is an Associate Professor in Department of Agribusiness and Applied Economics, NDSU.

contrast, wheat is ground into flour and directly consumed in breads, cakes, and other bakery products. In many countries, wheat is a staple food and a main source of nutrition.

Agriculture is in an age where more and more commodities contain specific attributes and are being produced for specific end-uses. Current GM technology directs its advantages mainly toward crop producers. Therefore, there is little reason for consumers to accept something new and unknown. This is problematic because today, more than ever, the consumer drives the market. Their tastes and preferences provide markets for products and return signals indicating future wants. Currently, consumers, especially in foreign markets, are rejecting GM foods, which should provide a signal to the agricultural industry.

The objective of this study is to estimate the impact of the introduction of GM wheat on the North Dakota wheat industry, other spring wheat regions both in the United States and Canada, and the hard red winter (HRW) wheat growing regions. Secondary objectives are to estimate price of GM wheat, show trade flow changes and levels, and estimate changes in consumer benefits.

The United States and Canada export hard red spring (HRS) wheats. The two countries produce similar types of HRS wheat, which are highly substitutable, and both export a large portion of their production to world markets, in many cases to the same importers. The United States also produces HRW wheat, which is a close substitute of HRS and Canadian Western Red Spring (CWRS) wheat.

Furtan et al. (2002) developed a model based on four groups of markets: the United States domestic market, the Canadian domestic market, foreign markets that accept both GM and non-GM wheat, and foreign markets that will accept only non-GM wheat. They assumed that the U.S. and Canadian domestic markets accept GM and non-GM wheat as perfect substitutes.

Furtan et al. found that if the United States were to license GM wheat first among the countries, the U.S. producer price would decrease from $C152.42 per metric ton to $C142.49 per metric ton, which is a difference of $C9.93 per metric ton, or $C0.27 per bushel. This price reduction would occur because the United States could no longer export wheat to countries that do not accept the GM wheat, allowing Canada and other competitors to fill the gaps in these markets. If both the United States and Canada licensed GM wheat, the researchers found that producer prices in the United States would decrease even further. This would occur because after licensing the GM variety, Canada would likely increase exports across the border, since the United States accepts GM wheat, which would cause U.S. domestic prices to fall further. If both Canada and the United States introduced GM wheat, the researchers estimate that the reduction in wheat prices would equal $C0.76 per bushel in the United States and $C0.81 per bushel in Canada. In another study, Kuntz (2001) estimated that the annual average price of CWRS wheat across all qualities of wheat would decrease $C13.95 per metric ton ($C0.38 per bushel), and that the annual average revenue to the pool account for CWRS wheat would decrease about $C185 million, if GM wheat was introduced in Canada.

The results from Furtan et al. are based on the assumption that the United States and Canada will not have an affordable system to segregate GM and non-GM wheat. The researchers believe that this is likely since the very low tolerance levels in a number of wheat-importing countries would make effective segregation costly. Furtan et al. assumed that if either the United States or Canada licenses GM wheat, importing countries will assume that all wheat produced in the United States or Canada contains some GM product because of the inability to distinguish between GM and non-GM wheat. Therefore, if either country licenses GM wheat, they will lose markets.

Reports from the U.S. Wheat Associates (April 2001 and 2002) confirm these assumptions. Representatives of the U.S. wheat industry traveled to Japan in April 2001 to discuss implications of GM wheat with Japan's industry leaders. They found that there was no market or consumer acceptance for GM wheat. The Japanese industry leaders indicated that they would purchase non-GM wheat from U.S. competitors if the United States could not guarantee that its wheat was GM-free. U.S. Wheat Associates reported that the development of an identity-preserved (IP) system is not enough to protect U.S. market share in Japan since the Japanese are skeptical of the reliability of any IP system. The view of the millers in Japan was that consumers would not purchase wheat products, even those labeled as "non-GM" or "segregated," for fear of contamination, and that consumers would readily shift from wheat to rice (U.S. Wheat Associates 2001).

U.S. Wheat Associates (2002) has reported similar views in Europe. Some of the largest buyers in the region stated that they will not buy U.S. wheat if GM wheat is produced in the United States because 1) consumers have strong opinions against GM foods, 2) they can buy cheap alternative supplies from other countries, and 3) they are skeptical of the ability to segregate GM from non-GM wheat (U.S. Wheat Associates 2002).

Another potential impact of GM HRS wheat introduction is the effect on durum wheat exports. The CEO of the largest wheat miller in Italy, Grandi Molini Italiani, stated that if the United States allows commercial production of GM wheat varieties, they will be forced to avoid importing from any wheat region in the United States. (Reuters News Service).

Other GM crops and foreign acceptance of them may provide information concerning future acceptance of GM wheat. The EU was a major importer of canola meal and honey from Canada. After the introduction of GM canola, exports of both fell to almost zero (Calgary Herald). Also, U.S. corn exports to the EU and S. Korea have fallen substantially since the introduction of GM corn. U.S. soybean meal exports to the EU have also fallen since the introduction of GM soybeans in the United States (USDA).

Because of consumer resistance and the lack of a credible segregation system, Furtan et al. found that there is no first-mover advantage in producing GM wheat. They found that benefits would transfer from wheat producers to biotech firms. The cost savings assumed from producing GM wheat is not nearly enough to overcome the reduced price caused by lost export sales.

Consumer confidence in government oversight is generally low in foreign countries. Previous experiences with food related health problems, for example mad-cow disease, have developed public mistrust in regulatory and other governmental agencies.

The handling/transportation system, in the future, may develop a system which is affordable and dependable, although past experience indicates that it will be very difficult, (e.g. Starlink® corn). Currently, that system is not available. Whether GM or non-GM wheat would be segregated is unknown at this time. The type of wheat to which the cost of segregation is applied depends mainly on the volume handled. If GM wheat is a minor crop, the cost of segregation will be directed toward GM wheat. On the other hand, if GM wheat becomes the dominant type produced, non-GM wheat will be segregated.

Farmers are not expected to plant 100% GM wheat. The adoption level of GM wheat is currently unknown. Each producer will estimate, for his own operation, costs and benefits of GM wheat production. GM wheat will be produced only if both the monetary and gains in terms of convenience exceed additional costs. Also, there is a crop rotation issue. Typically, producers will not produce glyphosate-tolerant wheat after glyphosate-tolerant soybeans, canola, or corn because of the cost to control volunteer crops and the increased potential for weeds to develop tolerance to glyphosate. Another factor limiting the adoption of glyphosate-tolerant wheat is that the common practice of applying glyphosate to dry wheat prior to harvest would become ineffective.

The next section of the paper develops a spatial equilibrium model to evaluate the trade impacts of the introduction of GM wheat. Following sections describe the data used for the analysis and the assumptions and scenarios used in the model. The results and conclusions are presented in subsequent sections.

METHODOLOGY

A spatial equilibrium model is developed to evaluate the trade impacts associated with GM wheat introduction and several plausible post-GM adoption scenarios. HRS, CWRS, and HRW wheat are modeled. HRS wheat is further divided into non-GM and GM variants. Substitution between spring and winter wheat is allowed by converting wheat into protein equivalents. HRS and CWRS wheat are assumed to contain 14% protein and HRW wheat is assumed to contain 12% protein. Both supply and demand for wheat are expressed in terms of 1,000 metric tons of protein. Results are then converted back to 1,000 metric tons of wheat for exposition.

The United States is divided into three producing regions: North Dakota, other spring wheat producing states, and a winter wheat growing region. Canada is divided into the four western provinces: Manitoba, Saskatchewan, Alberta, and British Columbia. The model also includes 26 countries which, together, import over 90% of the hard wheat produced by the United States and Canada, and a rest of the world region.

The objective function of the model is to maximize total consumer and producer surplus less transportation costs. As the model is an implicit price model, we sum the integrated inverse demand functions and quantity consumed in all importing countries, subtract the sum of the integrated inverse supply functions and quantity produced in all exporting countries, and the sum of transportation costs from producing regions to consuming regions plus cost saving for the production of GM wheat, as in (1).

$$\sum_i \left(\frac{(Q_i^d)^2}{2 \cdot b_i} - \frac{a_i \cdot Q_i^d}{b_i} \right) - \sum_j \left(\frac{(Q_j^s)^2}{2 \cdot f_j} - \frac{e_j \cdot Q_j^s}{f_i} \right) - \sum_i \sum_j q_{j,i}^s \cdot trans_{i,j} + \sum_j GM^s \cdot q_j^s \qquad (1)$$

i	= subscript denoting hard red wheat consuming region;
j	= subscript denoting hard red wheat producing region;
a_i	= intercept term of import demand equation for region *i;*
b_i	= price coefficient of import demand equation for region *i*;
e_j	= intercept term of export supply equation for region *j*;
f_j	= price coefficient of export supply equation for region *j*;
Q_j^s	= export supply from region *j*;
Q_i^d	= import demand from region *i;*
$trans_{i,j}$	= transportation cost from producing region *j* to consuming region *i*.
$q_{j,non}^s$ and $q_{j,gm}^s$	= quantity of non-GM and GM protein produced in region *j*;
$q_{i,non}^d$ and $q_{i,gm}^d$	= quantity of non-GM and GM protein consumed in region *i*;
GM^s	= production cost savings for GM wheat production.

The first term is the sum of consumer surplus in all importing countries, the second term represents the sum of producer surplus in all exporting countries, the third term is the sum of all transportation costs in shipping both GM and non-GM wheat from exporting countries to importing countries, and the fourth term is the cost savings of producing GM wheat.

Balance constraints are imposed to equate supply and demand for both GM and non-GM wheat.

$$q_{j,i}^s = q_{i,j}^d \ \forall i,j . \qquad (2)$$

And, total production and consumption are computed in (3) and (4):

$$Q_j^s = \sum_i q_{j,i}^s \ \forall j ; \qquad (3)$$

$$Q_i^d = \sum_j q_{i,j}^d \forall i . \qquad (4)$$

As price is implicit in this model formulation, prices paid and received must be imputed as the inverse of the demand and supply functions, both evaluated post-optimality.

Export commodity loan losses are computed after each scenario is calculated. As much of current U.S. sales of grain are to "cash" customers (EU, Japan, and S.Korea), GM adoption by U.S. producers may shift sales to "credit" customers, some of whom may default on the loans.

These expected loan losses are computed prior to GM adoption and post-GM adoption. Estimates on the likelihood and severity of default are taken from Diersen and Sherrick (2000). For several countries in our model, Diersen and Sherrick (2000) do not provide estimates of default. In these cases, averages from the developing countries are used.

DATA

Table 1 shows the average chemical cost in North Dakota and other spring wheat producing states. The eastern part of North Dakota has the highest costs of $11.50 per acre, whereas the western part of North Dakota has the lowest cost. The other spring wheat growing states were assumed to have similar chemical costs as North Dakota, i.e., Minnesota at $11.50/acre, South Dakota at $9.90/acre, and Montana at $8.70/acre. The cost for an application of glyphosate is assumed to be about $4.50 to $5.00/ acre. Average potential cost savings could be as large as $7.00 per acre in the eastern part of the region. The chemical costs for many producers are much higher than the average of $11.50.

Table 1. Chemical Costs for North Dakota Farmers

	$/acre
East	11.50
Central	9.90
West	8.70

Source: North Dakota Extension Service

GM wheat varieties will carry a technology fee (tech fee), which is charged by the seed company. The tech fee for glyphosate-tolerant wheat is unannounced, but for corn and soybeans it is in the $5.00 to $8.00/acre range (Abraham) and for canola it is about $11/acre. Herbicide costs for corn and soybeans are typically higher than those for wheat, in the range of $18.00 to $25.00/acre, so the cost savings potential is larger for corn and soybeans than for wheat. The lower cost savings for wheat limits the tech fee which can be charged by the seed company. The tech fee used in this study is assumed to be $4.00 per acre. The level of the tech fee is not critical to the results, as explained in the Assumption section below.

Table 2 shows the current trade flows for U.S. and Canadian hard wheat. The United States exports 5.47 million metric tons of HRS and 8.62 million metric tons of HRW wheat. The largest importer of HRS wheat is Japan at 1.34 million metric tons, followed by the EU and the Philippines. The largest importer of HRW wheat is Nicaragua at 1.68 million metric tons, followed by Egypt and Mexico. The largest importer of CWRS is Iran at 3.49 million metric tons, followed by Japan and the United States.

We hypothesize that wheat flows should shift when GM wheat is introduced into production. According to our model assumptions, U.S. HRS wheat exports to Japan, S. Korea, and the EU are expected to be partially or totally replaced by exports from Canada. The markets formerly served by Canadian exports would be switched to U.S. wheat. If GM spring wheat is produced in both the U.S. and Canada, segregated non-GM HRW could be a substitute for spring wheat. There are several countries with which the United States will not trade (Iran, Iraq, and

North Korea), but there is sufficient global import demand for hard wheat to provide markets for GM wheat.

Table 2. Current United States and Canadian Exports of Hard Wheat

	US-HRS	US-HRW	CAN-CWRS	Total
	------------------------1000 metric tons------------------------			
Bangladesh	0	0	243	243
Chile	0	4	201	205
China	175	0	661	836
Colombia	0	362	405	767
D. Republic	113	91	19	223
Ecuador	26	6	270	302
Egypt	27	1,526	99	1,652
EU	889	0	968	1,857
Guatemala	36	61	278	375
Indonesia	29	5	693	727
Iran	0	0	3,492	3,492
Iraq	0	0	262	262
Israel	4	562	0	566
Japan	1,343	981	1,242	3,566
Jordan	0	308	5	313
S. Korea	349	270	138	757
Malaysia	146	4	285	435
Mexico	95	1,182	577	1,854
Nicaragua	49	1,682	0	1,731
Peru	0	422	224	646
Philippines	700	3	436	1,139
S. Lanka		52	204	256
Taiwan	533	283	36	852
Thailand	163	65	171	399
UAE	36	32	312	380
US	0	0	1,128	1,128
Venezuela	113	127	482	722
Rest of World	640	596	1,466	2,702
Total	5,466	8,624	14,297	28,387

Source: USDA and Canada Grains Council

Production data for the regions in the United States are obtained from the USDA and data for Canada are obtained from the Canada Grains Council. A three-year average is used to lessen weather abnormalities. Current exports are obtained from the same sources. Table 3 shows the production and exportable supply of hard wheat by region. The domestic consumption of hard wheat for the United States and Canada is removed from the total supply to calculate exportable supply. Saskatchewan is the largest producer of spring wheat, followed by other spring wheat growing regions in the United States and Alberta. Winter wheat is grown only in the winter wheat region.

Table 3. Total Production and Exportable Supply of Hard Wheats

	Production		Exportable Supply	
	HRS	HRW	HRS	HRW
	----------------1000 metric tons---------------			
Manitoba	3928.0	0.0	1964.0	0.0
Saskatchewan	11267.4	0.0	5633.7	0.0
Alberta	6303.0	0.0	3151.5	0.0
British Columbia	100.4	0.0	50.2	0.0
North Dakota	5559.3	0.0	2779.7	0.0
Other Spring	6575.9	0.0	3288.0	0.0
Winter	0.0	25196.7		12598.4
Total		58930.7		29465.4

Source: USDA, Canada Grains Council

Table 4 shows the average prices received by farmers and market prices for hard wheat in Canada and the United States during the past three years. U.S. prices were obtained from the USDA and prices received by farmers in Canada were obtained from the annual reports of the Canadian Wheat Board.

Table 4. Prices Received By Farmers and Market Prices for Hard Red Spring and Hard Red Winter Wheat, Three Year Average, 1999-2001

	Farmer	Market
	------------US$/mt------------	
US-HRS	106.56	133.50
US-HRW	93.44	115.36
Canada-CWRS	114.80	

Source: USDA, Canadian Wheat Board

Table 5 shows the estimated import demand elasticities for the importing countries. The elasticities were adapted for the model (Koo and Taylor). Import demand is inelastic in most countries, indicating that a change in price will have little impact on the level of imports.

Hard red wheat (protein) import demand equations are derived for 27 regions using elasticity estimates, historical price data, and historical consumption data (USDA). Again, all quantities and prices are converted into their protein equivalents to allow substitution between spring and winter wheat. Protein import demand equations are given as:

$$Q_i^d = a_i + b_i \cdot P_i^{paid} . \tag{5}$$

where

P_i^{paid} =price paid by consuming region *i*.

Calibrated demand equation parameters are reported in Table 5.

Table 5. Calibrated Protein Import Demand Equation Parameters

Region	Elasticity	Intercept a_i	Price coef. b_i	Region	Elasticity	Intercept a_i	Price coef. b_i
Bangladesh	-0.02	34.700	-5.038e-7	Jordan	-0.02	38.413	-5.503e-7
Chile	-0.3	37.206	-6.541e-6	Malaysia	-0.492	67.510	-5.018e-6
China	-0.016	118.854	-1.416e-6	Mexico	-0.11	306.696	-5.714e-5
Colombia	-0.3	130.182	-2.328e-5	Nicaragua	-0.3	271.310	-4.922e-5
D. Republic	-0.3	38.220	-6.934e-6	Peru	-0.3	106.600	-1.915e-5
Ecuador	-0.3	54.808	-9.899e-6	Philippines	-0.3	176.934	-1.34e-5
Egypt	-0.001	200.991	-1.562e-7	S. Korea	-0.11	150.065	-3.864e-5
EU	-0.012	263.022	-2.387e-6	S. Lanka	-0.02	35.496	-4.990e-7
Guatemala	-0.3	66.664	-1.210e-5	Taiwan	-0.021	116.006	-1.844e-6
Indonesia	-0.11	112.865	-8.271e-6	Thailand	-0.11	60.562	-4.581e-6
Iran	-0.02	498.402	-6.989e-6	UAE	-0.02	53.611	-7.514e-7
Iraq	-0.02	37.414	-5.244e-7	U.S.	-0.5	236.880	-6.985e-5
Israel	-0.02	69.360	-9.936e-7	Venezuela	-0.291	127.215	-2.264e-5
Japan	-0.006	482.402	-2.147e-6	ROW	-0.02	373.687	-5.702e-6

Source: Global Wheat Policy Simulation Model

Table 6 shows the export supply elasticities for the United States and Canada. The export supplies for all wheat classes are relatively inelastic, indicating that a change in prices will have a small impact on export supply.

Export supply equations are developed for seven North American hard wheat producing regions. CWRS wheat producing regions are Alberta, British Columbia, Manitoba, and Saskatchewan. HRS wheat producing regions are North Dakota and other U.S. spring wheat producing states. U.S. HRW wheat producing regions are aggregated into one region. These protein export supply equations take the form of:

$$Q_j^s = e_j + f_j \cdot P_j^{rec} . \tag{6}$$

where

P_j^{rec} =price received by producing region *j*.

Supply equation parameters are calibrated to historical exports measured in 1,000 metric tons of protein and historical prices received for wheat again in protein equivalents. Elasticity estimates are obtained from the Global Wheat Policy Simulation Model (Taylor and Koo). The resulting export supply equation parameters are reported in Table 6.

Table 6. Calibrated Protein Export Supply Equation Parameters

Region	Elasticity	Intercept e_j	Price coefficient f_j
Alberta	0.31	280.557	1.537e-6
British Columbia	0.31	4.451	2.439e-9
Manitoba	0.31	174.871	9.580e-5
Saskatchewan	0.31	501.530	2.748e-4
North Dakota	0.21	283.358	9.896e-5
Other spring wheat states	0.21	335.123	1.170e-4
U.S. winter wheat states	0.187	1321.527	3.903e-4

Shipping rates for U.S. wheat are calculated from U.S. Waybill data for rail shipments and from the American Marketing Service (AMS website) for barge shipments. Canadian shipping rates are obtained from published rates by the Canadian National Railways. Ocean shipping rates are adapted from rates obtained from Richardson Lawrie Associates (RLA). The shipping matrix between exporters and importers is developed utilizing a least-cost transportation method. Transportation costs were calculated for each origin-destination route, and the least-cost route was chosen. The transportation matrix is shown in Appendix Table 1.

Many importing countries or companies utilize credit for the purchase of imported goods. These countries or firms may potentially default on all or part of the loan. The developed countries of Japan, the EU, Israel, China, Canada, and Taiwan do not present that risk. Data from Dierson and Sherrick (2000) indicate the default risk and the severity of a default (see Table 7). In most cases, the potential financial risk is very small. Jordan, for example, runs a 7.1% risk of defaulting on a loan, but the severity of the default is 0.2% of the total loan value, for a financial loss of 0.014% of the value of the loan. Egypt has a 5.4% chance of defaulting on a loan, but the severity is 0.4%, for a financial loss of 0.022%. The risk in most cases is \$0.02 to \$0.03 per metric ton.

Table 7. Default and Severity of Export Loans for U.S. Export Customers

	Default	Severity
Bangladesh	0.042	0.04
Chile	0.042	0.04
China	0	0
Colombia	0.042	0.04
D. Republic	0.042	0.04
Ecuador	0.042	0.04
Egypt	0.054	0.004
EU	0	0
Guatemala	0.042	0.04
Indonesia	0.023	0.105
Iran	0.042	0.04
Iraq	0.042	0.04
Israel	0	0
Japan	0	0
Jordan	0.071	0.002
S. Korea	0.009	0.002
Malaysia	0.042	0.04
Mexico	0.038	0.031
Nicaragua	0.042	0.04
Peru	0.042	0.04
Philippines	0.042	0.04
S. Lanka	0.056	0.096
Taiwan	0	0
Thailand	0	0
UAE	0	0
US	0	0
Venezuela	0.042	0.04
ROW	0.042	0.04
Canada	0	0

Source: Dierson and Sherrick

ASSUMPTIONS AND SCENARIO DESCRIPTIONS

Eleven scenarios are evaluated in this study. Table 8 explains the various scenarios. A baseline scenario is developed with which to compare all other scenarios. Even though current production costs for glyphosate-tolerant soybeans are higher than non-GM soybeans, 75% of the soybean production in the United States consists of GM soybeans. The convenience of weed control must provide the incentive to produce GM soybeans. For this study, to bring GM wheat into the solution, production costs are assumed to be $2 per acre less than for non-GM wheat, which may be considered a convenience value. Scenario 1 assumes that the U.S. marketing/transportation system will not be able to develop an affordable and reliable method of segregation. Therefore, under scenario 1, the EU, Japan, and S. Korea will not purchase any wheat from the United States. Only one scenario was reported with unsuccessful segregation because no combination of the other assumptions provided positive results. Scenario 2 allows for the production of GM wheat in both North Dakota (ND) and other spring wheat (OSR) growing regions of the United States with successful segregation. Yields are assumed to be equal in all scenarios except for 5, 8, and 10. These scenarios allow for a 10% increase in yields. Agronomically, glyphosate-tolerant wheat is similar to other varieties except for the glyphosate-resistant gene. Yield potential and other agronomic factors within the seed are similar, so any yield increases will be a result of less chemical damage and less weed competition, although this has not been documented with soybeans.

The three countries/regions which will not accept GM wheat are Japan, the EU, and S. Korea; these countries together import 2.58 million metric tons of HRS wheat, 1.25 million metric tons of HRW, and 1.66 million metric tons of CWRS wheat. If the United States produces GM spring wheat, those markets will transfer to CWRS or U.S. non-GM segregated HRW wheat. There is concern that the U.S. marketing system will not be able to segregate GM wheat from non-GM wheat regardless of the class. For this study, an assumption was made both ways. For scenarios 2 through 10, it was assumed that a segregation system could be developed. However, for scenario 1, it is assumed that the U.S. marketing system will not be able to segregate GM from non-GM wheat. A segregation fee of $2.23/metric ton is applied to non-GM wheat exported to Japan, the EU, and S. Korea. There has been a wide debate on what that cost would be. Estimates range from $1.30 per metric ton to over $16 per metric ton depending on what is included in the cost, i.e., segregation, sampling, testing (both domestically and foreign), reporting, and insurance (Wisner). If a segregation system is not affordable, GM wheat production will not be profitable. Therefore, a level was chosen that could provide separation but at the same time not prevent GM wheat production.

Scenario 3 prevents GM wheat production in North Dakota. All other factors remain constant. The scenario evaluates the impact on North Dakota if the state government prevents GM wheat production in North Dakota. Scenario 4 allows GM wheat production in ND and OSR but only at the 30% adoption level. Many producers within the production regions, especially in the western areas, may not produce GM wheat because their herbicide cost is less than the cost for GM wheat. Also, rotational concerns will affect the production of a second GM crop. Scenario 5 allows GM wheat production in ND and OSR but with a 10% yield increase over non-GM wheat. Monsanto has indicated that a 10-15% yield increase is possible because of less weed competition and less crop herbicide damage. Scenario 6 allows GM wheat production in both the United States and Canada. Scenario 7 allows GM wheat production in both but at the 30% adoption level. Likewise, scenario 8 allows for a 10% yield increase for GM wheat in the two countries. At this time, it is unknown whether GM wheat will be segregated from non-GM wheat or non-GM will be segregated from GM wheat. Scenarios 9 and 10 place the segregation fee on GM wheat instead of on non-GM wheat. If the marketing system in the

United States treats GM wheat as a minor commodity, it is possible that GM wheat will carry the segregation cost instead of non-GM wheat.

Table 8. Explanation of the Various GM Wheat Scenarios Considered in the Study

Baseline	Wheat flows with no GM wheat produced
Scenario 1	GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea
Scenario 2	GM wheat production allowed in regions ND and OSR
Scenario 3	GM wheat production allowed in only OSR
Scenario 4	GM wheat production allowed in regions ND and OSR at the 30% adoption level
Scenario 5	GM wheat production allowed in regions ND and OSR but with a 10% yield increase
Scenario 6	GM wheat production allowed in all spring wheat growing regions of the U.S. and Canada
Scenario 7	GM wheat production allowed in all spring wheat growing regions of the U.S. and Canada at the 30% adoption level
Scenario 8	GM wheat production allowed in all spring wheat growing regions of U.S. and Canada but with a 10% yield increase
Scenario 9	GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee applied to GM wheat
Scenario 10	GM wheat production allowed in regions ND and OSR but with a 10% yield increase and the segregation fee applied to GM wheat

RESULTS

Export Volume

Table 9 shows the exports of hard wheat under the various scenarios. Under most scenarios, there is little change in export volume, if segregation is successful. The results change if the U.S. marketing/transportation system is unable to segregate GM wheat from non-GM wheat (scenario 1). North Dakota's exports are reduced 2.1% (7,460 metric tons), other spring wheat region exports are reduced 2.0% (8,830 metric tons), and the winter wheat region exports are reduced 2.2%. Canadian exports increase 4.4%. When GM wheat is produced with successful segregation (scenario 2), export volumes increase slightly for the producing regions of ND and OSR. The other producing regions export slightly less wheat under scenario 2. Total trade volume increases by 1,770 metric tons, or 0.04%. When North Dakota is prevented from producing GM wheat (scenario 3), wheat exports from North Dakota decrease slightly along with the other non-GM wheat producing regions. Export volume for OSR increases by 2,090 metric tons. When the adoption rate for GM wheat is limited to 30%, ND and OSR increase their exports, but at lower levels than those under scenario 2. If the yield for GM wheat is increased 10% (scenario 5), production increases by 13,640 metric tons for ND and 16,120 metric tons for OSR. Total exports increase by 9,440 metric tons. Other non-GM wheat producing regions lose exports.

The scenarios which allow Canadian producers to produce GM wheat (scenarios 6, 7, and 8) are similar to the scenarios for U.S. production. Canadian exports of wheat increase slightly under these scenarios. The winter wheat region in the United States loses exports. If the segregation fee is applied to GM wheat, there is little or no change in export levels.

Table 9. Exports of Hard Wheat By Region Under Various Scenarios

	ND	OSR	WR	Man	SK	Alb	BC	Total
	----------------------------------1000 metric tons--------------------------------------							
Baseline	365.82	432.66	1652.27	264.67	736.47	418.05	6.64	3876.58
1	358.36	423.83	1616.30	275.98	768.91	436.20	6.93	3886.51
2	367.59	434.75	1651.39	264.45	735.84	417.70	6.63	3878.35
3	365.58	436.09	1651.32	264.43	735.79	417.68	6.63	3877.52
4	366.32	433.23	1651.99	264.60	736.28	417.92	6.64	3876.98
5	379.46	448.78	1643.63	262.55	730.37	414.65	6.58	3886.02
6	367.51	434.65	1651.04	264.94	737.24	418.49	6.64	3880.51
7	365.78	432.61	1652.12	264.63	736.35	417.99	6.64	3876.12
8	376.13	444.86	1630.53	269.70	750.89	426.12	6.77	3905.00
9	365.83	432.66	1652.28	264.67	736.47	418.06	6.64	3876.61
10	365.83	432.66	1652.28	264.67	736.47	418.06	6.64	3876.61
Difference								
1	-7.46	-8.83	-35.97	11.31	32.44	18.15	0.29	9.93
2	1.77	2.09	-0.88	-0.22	-0.63	-0.35	-0.01	1.77
3	-0.24	3.43	-0.95	-0.24	-0.68	-0.37	-0.01	0.94
4	0.50	0.57	-0.28	-0.07	-0.19	-0.13	-0.00	0.40
5	13.64	16.12	-8.64	-2.12	-6.10	-3.40	-0.06	9.44
6	1.69	1.99	-1.23	0.27	0.77	0.44	0.00	3.93
7	-0.04	-0.05	-0.15	-0.04	-0.12	-0.06	0.00	-0.46
8	10.31	12.20	-21.74	5.03	14.42	8.07	0.13	28.42
9	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.03
10	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.03

Baseline) Current wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Adoption

Table 10 shows the GM wheat production shares for the various scenarios. Under scenario 1, both spring wheat growing regions in the United States produce 100% GM wheat. When GM wheat is produced and segregated, all of the wheat produced in OSR is GM wheat and almost 76% of the wheat produced in ND is GM wheat. When yields are increased 10%, all of the spring wheat produced in ND and OSR is GM wheat. Canada produces 80.9% GM wheat when they are not restricted in GM output. If the segregation fee is placed on GM (scenario 10) and yields are increased, GM wheat production in ND is 48.1% of the total wheat produced, OSR produces 46.8% GM wheat, and Canada produces 100% GM wheat.

Table 10. GM Wheat Production Shares By Region Under Various Scenarios

Scenarios	1	2	3	4	5	6	7	8	9	10
	--percent--									
ND	100.0	75.9	0.0	30.0	100.0	100.0	30.0	99.0	30.0	48.1
OSR	100.0	100.0	100.0	30.0	100.0	88.1	30.0	100.0	30.0	46.8
Canada	0.0	0.0	0.0	0.0	0.0	80.9	30.0	100.0	30.0	100.0

Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Producer and Consumer Welfare

Table 11 shows the total producer welfare under the various scenarios. Producer welfare drops for the spring wheat growing region under scenario 1. When no trade is allowed with the EU, Japan, or S. Korea, because of unsuccessful segregation, producer welfare for North Dakota drops $27.3 million (10.1%). In the OSR, the producer welfare under this scenario drops $32.3 million (10.1%). The winter wheat region also loses producer welfare because HRW wheat is viewed as being mixed with GM spring wheat. The producer welfare for the winter wheat region drops $150.7 million (12.0%). The percentage drop for the winter wheat region is larger because the growers do not have the advantage of lower production costs. Producer welfare for the Canadian growers increases $171.2 million (16.7%).

When GM wheat is allowed, and segregation is successful, North Dakota's producer welfare increases by $6.55 million and the producer welfare for the OSR increases by $7.74 million. The other regions lose producer welfare. When North Dakota is prevented from growing GM wheat, producer welfare decreases by $910,000. If yields are increased 10%, producer welfare increases $51.32 million in North Dakota and $60.69 million in the OSR. Producer welfare in the winter wheat region in the United States and Canada falls $36.54 million and $31.33 million, respectively. If GM wheat is also grown in Canada, producer welfare in Canada increases by $4.01 million. When yields are increased 10%, producer welfare increases $75.23 million, or $19.28 per bushel. It remains relatively unchanged from the baseline when the segregation fee is applied to GM wheat. Producer welfare increases $2.50 per metric ton when GM wheat is produced (Table 12), if segregation is successful. If North Dakota is prevented from GM wheat production, the producer welfare decreases $0.35 per metric ton, but it increases $4.11 per metric ton for OSR. When GM wheat is grown in the United States and Canada, producer welfare increases $0.40 per metric ton in Canada and $2.38 per metric ton in the United States. When the segregation fee is charged to GM wheat, there is no change from the baseline in producer welfare. Under scenario 1, producer welfare drops $10.56 per metric ton, or about $0.29 per bushel for spring wheat and $0.30 per bushel for winter wheat, because of the loss of all wheat trade with Japan, S. Korea, and the EU. Producer welfare for Canadian producers under this scenario increase $16.53 per metric ton, or about $0.45 per bushel.

Table 13 shows the total consumer welfare under the various scenarios. Consumer welfare changes very little except under the two scenarios which allow for a yield increase; however, even under these scenarios, the change is less than 0.1%. Consumers do benefit from GM wheat production, but the benefit is very small.

Table 11. Total Producer Welfare Under Various Scenarios

	ND	OSR	WR	Man	SK	Alb	BC
	---------------------------------Million $------------------------------------						
Baseline	270.48	319.90	1,259.97	206.01	529.30	312.48	4.97
1	243.17	287.59	1,109.32	237.93	618.18	362.92	5.77
2	277.03	327.64	1,256.19	205.40	527.61	311.53	4.96
3	269.58	332.64	1,255.88	205.35	527.48	311.45	4.95
4	272.51	322.30	1,258.08	205.70	528.51	312.02	4.97
5	321.80	380.59	1,223.43	200.16	513.04	303.25	4.82
6	276.71	327.26	1,254.73	206.76	531.38	313.67	4.99
7	270.33	319.71	1,259.26	205.89	528.98	312.30	4.97
8	309.12	365.59	1,168.47	220.04	568.34	334.64	5.32
9	270.49	319.91	1,260.01	206.01	529.32	312.50	4.97
10	270.49	319.91	1,260.01	206.01	529.32	312.50	4.97
Difference							
1	-27.32	-32.31	-150.65	31.92	88.88	50.44	0.80
2	6.55	7.74	-3.78	-0.61	-1.69	-0.96	-0.02
3	-0.91	12.74	-4.09	-0.65	-1.82	-1.03	-0.02
4	2.03	2.40	-1.89	-0.31	-0.79	-0.47	0.00
5	51.32	60.69	-36.54	-5.84	-16.26	-9.23	-0.15
6	6.22	7.36	-5.24	0.75	2.08	1.18	0.02
7	-0.16	-0.19	-0.71	-0.11	-0.32	-0.18	-0.00
8	38.64	45.69	-91.50	14.03	39.04	22.16	0.35
9	0.01	0.01	0.04	0.01	0.02	0.01	0.00
10	0.01	0.01	0.04	0.01	0.02	0.01	0.00

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Table 12. Producer Welfare Per Metric Ton of Wheat Exported

	ND	OSR	WR	Man	SK	Alb	BC
	---------------------------------------$/metric ton--						
Baseline	116.66	116.66	101.69	131.23	119.71	125.24	125.52
1	106.10	106.10	90.62	147.76	136.24	141.77	142.05
2	119.16	119.16	101.41	130.91	119.39	124.92	125.20
3	116.32	120.77	101.39	130.89	119.37	124.90	125.18
4	117.54	117.54	101.43	131.36	119.84	125.37	125.65
5	135.94	135.94	99.02	128.13	116.61	122.14	122.42
6	119.04	119.04	101.30	131.63	120.11	125.64	125.92
7	116.60	116.60	101.63	131.17	119.65	125.18	125.46
8	131.24	131.24	95.00	138.58	127.06	132.59	132.87
9	116.67	116.67	101.69	131.24	119.72	125.25	125.53
10	116.67	116.67	101.69	131.24	119.72	125.25	125.53
Difference From Base							
1	-10.56	-10.56	-11.06	16.53	16.53	16.53	16.53
2	2.50	2.50	-0.27	-0.32	-0.32	-0.32	-0.32
3	-0.35	4.11	-0.30	-0.35	-0.35	-0.35	-0.35
4	0.87	0.87	-0.25	-0.13	-0.13	-0.13	-0.13
5	19.28	19.28	-2.66	-3.10	-3.10	-3.10	-3.10
6	2.38	2.38	-0.38	0.40	0.40	0.40	0.40
7	-0.06	-0.06	-0.05	-0.06	-0.06	-0.06	-0.06
8	14.58	14.58	-6.69	7.35	7.35	7.35	7.35
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Table 13. Consumer Welfare Under Various Scenarios

	Total	Difference From Base
	--------------Million $--------------	
Baseline	24,826.67	
1	24,878.70	2.03
2	24,827.85	1.18
3	24,827.58	0.91
4	24,826.96	0.29
5	24,835.75	9.08
6	24,829.64	2.97
7	24,825.89	(0.78)
8	24,855.43	28.76
9	24,827.07	0.40
10	24,827.07	0.40

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Table 14 shows the total welfare for the system under the various scenarios. Total welfare changes very little. In the scenarios which allow for the yield to increase, total welfare increases $135.3 million when U.S. production of GM wheat is allowed and $356.2 million when both US and Canadian production is allowed. The increases are 0.05% and 0.14%, respectively. Under scenario 1, total welfare is reduced with the introduction of GM wheat in the United States because of the loss of hard wheat exports.

Table 14. Total Welfare For the System Under Various Scenarios

	Total	Difference From Base
	-----------Million $------------	
Baseline	251,170	
1	251,153	-17.92
2	251,188	18.77
3	251,183	13.82
4	251,183	13.36
5	251,305	135.27
6	251,212	42.14
7	251,188	18.45
8	251,526	356.22
9	251,180	10.82
10	251,241	70.95

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Prices

Table 15 shows the estimated prices for GM and non-GM wheat and the differences between the prices. Under an equilibrium system, the price of GM wheat should fall by the production cost savings less the segregation fee and the amount of default on the loans. In most cases, GM wheat is about $2.10 to $2.15 per metric ton less than non-GM wheat. The reason that the price difference under the ND scenario is $0.55 is that North Dakota cannot produce GM wheat, which restricts the supply of GM wheat. The price difference under the two scenarios which place the segregation fee on GM wheat (9 and 10) is approximately $4.15 per metric ton, which reflects the $2.33 per metric ton segregation fee. Under scenario 1, the price drops $10.56 per metric ton, or about $0.29 per bushel, in the United States with unsuccessful segregation.

Imports and Trade Flows

Table 16 shows imports of wheat under various scenarios. The level of imports does not change very much. The only change that occurs is under the two scenarios in which yields are increased by 10%. Imports increase by 72,000 metric tons when U.S. GM wheat yields are increased and by 218,000 metric tons when both U.S. and Canadian GM wheat yields are increased. Under these two scenarios, there is a price decrease of $5 to $8 per metric ton, and imports respond to the lower price levels.

Table 17 shows trade flows of non-GM wheat to the EU, Japan, and S. Korea. Under the baseline scenario, the EU obtains its imports from North Dakota, and Japan and S. Korea import from Canada. Under scenario 1, Japan, S. Korea, and the EU import wheat from Canada because of unsuccessful wheat segregation in the United States. The level is slightly less than in the baseline scenario because of higher wheat prices in Canada. When GM is introduced in scenario 2, the EU imports most of their hard wheat requirements from the winter wheat region if segregation is successful. Japan and S. Korea continue to import from Canada. When North Dakota is prevented from producing GM wheat, export trade flows return to the baseline scenario. Under scenario 4, North Dakota exports 1.75 million metric tons to the EU and the other states export 0.85 million metric tons. When yields are increased under scenario 5, the EU imports HRW wheat instead of HRS wheat. When Canada produces GM wheat, most of the imports are shifted to HRW wheat. Canada still exports 0.24 million metric tons to Japan under this scenario. If the adoption rate of GM wheat is limited to 30%, North Dakota exports 57,900 metric tons to the EU, and Canada supplies all the exports to Japan and S. Korea. If yields are increased 10%, all the exports are from the winter wheat region. When the segregation fee is added to GM wheat instead of non-GM wheat, under scenario 9, North Dakota exports 0.11 million metric tons to the EU with the remaining hard wheat coming from the winter wheat region. Japan and S. Korea import from Canada. When yields are increased 10%, North Dakota and the ORS export to the EU, Canada exports to S. Korea, and Japan imports HRW wheat.

Table 15. Estimated Price for GM and Non-GM Wheat

	Non-GM	GM	Difference
	--------------------$/metric ton---------------------		
Baseline	116.66		
1		106.10	
2	116.85	114.71	2.14
3	116.32	115.77	0.55
4	114.36	112.21	2.15
5		111.45	
6	116.68	114.58	2.10
7	114.26	112.15	2.11
8		106.75	
9	114.38	110.24	4.14
10	113.96	109.81	4.15

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Table 16. Imports of Hard Wheat Under Various Scenarios

Scenarios	Baseline	1	2	3	4	5	6	7	8	9	10
	----------------------------------1,000 metric tons--										
Bangladesh	263	263	263	263	263	263	263	263	263	263	263
Chile	231	236	231	231	231	232	231	231	235	231	231
China	903	904	903	903	903	903	903	903	903	903	903
Colombia	819	836	820	820	819	823	820	819	829	819	819
D.Republic	240	245	240	240	240	241	240	240	243	240	240
Ecuador	342	349	343	343	342	344	343	342	347	342	342
Egypt	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545
EU	2,004	2,000	2,004	2,004	2,004	2,004	2,004	2,004	2,005	2,004	2,004
Guatemala	419	427	419	419	419	421	419	419	424	419	419
Indonesia	793	799	793	794	793	795	795	793	800	793	793
Iran	3,766	3,760	3,766	3,766	3,766	3,767	3,768	3,766	3,773	3,766	3,766
Iraq	283	284	283	283	283	283	283	283	284	283	283
Israel	525	526	526	525	525	526	526	525	526	525	525
Japan	3,692	3,690	3,692	3,692	3,692	3,693	3,692	3,692	3,693	3,692	3,692
Jordan	291	291	291	291	291	291	291	291	291	291	291
Korea	825	790	826	826	825	832	820	821	836	825	825
Malaysia	475	478	475	475	475	476	476	475	479	475	475
Mexico	1,913	1,960	1,919	1,914	1,913	1,929	1,919	1,913	1,944	1,913	1,913
Nicaragua	1,704	2,047	1,705	1,705	1,704	1,713	1,705	1,704	1,725	1,704	1,704
Peru	666	679	666	666	666	669	666	666	674	666	666
Philippines	1,244	1,253	1,244	1,244	1,244	1,246	1,247	1,244	1,257	1,244	1,244
S. Lanka	269	269	269	269	269	269	269	269	269	269	269
Taiwan	876	878	876	876	876	877	877	876	878	876	876
Thailand	426	429	426	426	426	427	427	426	430	426	426
UAE	406	407	406	406	406	406	406	406	406	406	406
US	1,270	1,207	1,271	1,271	1,270	1,282	1,286	1,270	1,336	1,270	1,270
Venezuela	801	820	804	802	801	808	804	801	814	801	801
ROW	2,829	2,833	2,829	2,829	2,829	2,830	2,829	2,829	2,831	2,829	2,829
Total	29,820	30,204	29,833	29,827	29,820	29,892	29,850	29,816	30,038	29,820	29,820

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Table 17. Sources of Non-GM Wheat for the EU, Japan, and Korea Under Various Scenarios

Exporter Importer Class	ND EU HRS	OSR EU HRS	WR Korea HRW	WR EU HRW	WR Japan HRW	Canada Japan CWRS	Canada Korea CWRS	Canada EU CWRS	Total
	---------------------------------1000 metric tons--------------------------------------								
Baseline	1860.7	0.0	0.0	0.0	0.0	3428.6	767.1	0.0	6056.4
1	0.0	0.0	0.0	0.0	0.0	3428.6	733.6	1857.1	6019.3
2	370.0	0.0	0.0	1739.2	0.0	3381.4	767.1	0.0	6257.7
3	1860.7	0.0	0.0	0.0	0.0	3381.4	767.1	0.0	6009.3
4	1255.7	605.0	0.0	0.0	0.0	3428.6	766.4	0.0	6055.7
5	0.0	0.0	0.0	2170.8	0.0	3428.6	772.1	0.0	6371.5
6	0.0	0.0	888.3	2170.8	1718.3	1955.0	0.0	0.0	6732.5
7	413.6	0.0	0.0	1690.8	0.0	3428.6	762.1	0.0	6295.1
8	0.0	0.0	905.8	2171.7	4000.8	0.0	0.0	0.0	7078.3
9	767.9	0.0	0.0	1275.8	0.0	3428.6	766.4	0.0	6238.7
10	767.9	1093.6	0.0	0.0	4000.0	0.0	766.4	0.0	6627.9

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

Loan Defaults

Table 18 shows the losses due to loan defaults by importing countries. Compared to total welfare, the losses are very small. Under the Baseline scenario, the losses are $150,000 for North Dakota exports and $2.05 million for HRW wheat. When GM wheat is produced, losses are $250,000 for North Dakota wheat and $1.98 million for HRW wheat. Total U.S. losses are $2.46 million under the baseline scenario and $2.47 million under scenario 2.

Table 18. Losses Due To Commodity Loan Defaults

	ND	OSR	WR
	------------------Million $-----------------		
Baseline	0.15	0.26	2.05
1	0.17	0.30	1.84
2	0.25	0.24	1.98
3	0.15	0.27	2.05
4	0.12	0.29	2.05
5	0.29	0.39	1.85
6	0.19	0.31	1.55
7	0.25	0.16	2.05
8	0.28	0.37	1.14
9	0.12	0.29	2.05
10	0.12	0.29	2.05

Baseline) Baseline wheat flows; Scenario 1) GM wheat production allowed in regions ND and OSR, no wheat trade with the EU, Japan, or S. Korea; 2) GM wheat production allowed in all spring wheat regions; 3) GM wheat production allowed in only region OSR; 4) GM wheat production allowed in regions ND and OSR at the 30% adoption level; 5) GM wheat production allowed in regions ND and OSR but with a 10% yield increase; 6) GM wheat production allowed in all spring wheat growing regions of both countries; 7) GM wheat production allowed in all spring wheat growing regions of both countries at the 30% adoption level; 8) GM wheat production allowed in all spring wheat growing regions of both countries with a 10% yield increase; 9) GM wheat production allowed in regions ND and OSR at the 30% adoption level and the segregation fee is applied to GM wheat; 10) GM wheat production allowed in regions ND and OSR with a 10% yield increase and the segregation fee is applied to GM wheat.

CONCLUSIONS

The potential introduction of GM wheat has raised consumer concerns over the safety of the product. Other GM crops were introduced with limited protest from the consuming public, but Japan, the European Union, and S. Korea have stated that they will not import GM wheat. Many other nations have raised concerns about GM foods and have developed labeling requirements indicating GM ingredients.

Previous research on the impacts of GM adoption were based on the assumption that the United States and Canada will not develop an affordable system to segregate GM and non-GM wheat. Therefore, if either country licenses GM wheat, they will lose markets that will not accept GM wheat because all wheat will be viewed as containing some GM material. However, if there is a potential return to be generated for the handling/transportation system with segregation, the means or processes may be developed to assure that segregation occurs, although there is no indication that it is possible. This study looked at both assumptions. Since it is unknown at this time whether GM wheat and non-GM wheat will be segregated, as in the case of soybeans, both cases are addressed in this study.

The objective of this study is to estimate the impact of the introduction of GM wheat on the North Dakota wheat industry, other spring wheat regions both in the United States and Canada, and the HRW wheat growing regions. Secondary objectives are to estimate price levels, producer benefits, trade flow changes, and changes in consumer benefits.

A spatial equilibrium model is developed to evaluate the trade impacts associated with GM wheat introduction and several plausible post-GM adoption scenarios. Both HRS wheat and HRW wheat are modeled, and HRS wheat is divided into non-GM and GM categories. Substitution between spring and winter wheat is allowed by converting wheat into protein equivalents. The United States was divided into three producing regions and Canada was divided into the four western provinces. There are 26 importing countries and a rest of the world region.

The total trade volume of exported hard wheat changes very little under the various scenarios. Since import demand is inelastic, imports remain relatively constant with small changes in price, but there is a change in trade flows. When GM wheat is introduced, the countries restricting GM wheat import non-GM wheat from other sources resulting in little change in volume or price. Prices for GM wheat typically are $2.10 to $2.15 per metric ton less than non-GM wheat, except for the scenario in which segregation is unsuccessful. GM wheat price is about $4.14 per metric ton less when segregation fees are applied to GM wheat. If the U.S. marketing/transportation system is unable to develop an affordable and dependable segregation system, the price of all U.S. wheat falls about $11 per metric ton, or about $0.30 per bushel.

Welfare for producers who raise GM wheat increases slightly at the expense of both non-GM wheat producers and HRW wheat producers. Both total producer and consumer welfare increase slightly when GM wheat is produced, if segregation is successful.

Several issues concerning GM wheat remain to be studied. The glyphosate-tolerant gene is identifiable; therefore, that attribute can be priced. Since the GM trait is viewed as a negative attribute in many markets, it can be expected to result in a price discount. Importing countries who accept GM wheat will import it at a discount. Also, U.S. millers and bakers may discount GM wheat because the GM attribute is identifiable. The discount price is unknown at this time.

Producers will not produce GM wheat just because it is available. The production cost savings and convenience will have to offset the higher seed cost. Also, if the market price for GM wheat is substantially lower than for non-GM wheat, it may not be adopted by producers. There are also rotational concerns with the production of a second GM crop. The volunteer GM crop is difficult to control if followed by another GM crop.

The ability of the transportation and marketing system in the United States to develop a method to segregate GM and non-GM wheat is a major unknown factor at this time. If an affordable and dependable system cannot be developed, all wheat from the United States will be viewed as GM wheat regardless of the class. In that case, the U.S. will lose all the markets for countries who reject GM wheat. That loss of markets may include other classes of wheat. Also, if a price discount occurs, all U.S. wheat would face that discount, in which case, the production of GM wheat would reduce wheat prices in the United States and producer welfare.

The study indicates that the main determining factor for the profitability of GM wheat production is the ability of the marketing/transportation system to develop a segregation system which is affordable, dependable, and acceptable to foreign consumers. The consumer has become the driving force in agriculture today. More and more commodities are being produced for specific end-uses and with specific attributes. Importers, along with the consumers, will need to accept the integrity of a segregation system, which will allow them to purchase segregated non-GM wheat from the United States. If that acceptance can not be developed, the introduction of GM wheat, while benefitting a few producers, will lower total producer welfare in the United States.

References

Abraham, Harvey. District Sales Manager, Mycogen Seeds. Personal communication. March 2003.

American Marketing Service website. http://www.ams.usda.gov.

Calgary Herald. "Mosanto Seeks Approval for Genetically Modified Wheat." Edmonton, Alberta. January 8, 2003.

Canada Grains Council. *Canadian Grains Industry: Statistical Handbook*. 2000 and 2001. Winnipeg, Manitoba.

Canadian National Railways website. http://www.cn.ca/en_index.shtml.

Canadian Wheat Board website. http://www.cwb.ca/en/index.jsp.

Dierson, Matthew, and Bruce J. Sherrick. "Developing More Complete Estimates of Repayment Capacity Distributions: Application to Export Credit Guarantees." Proceedings of NG-221 Annual Meeting, Federal Reserve Bank of Minneapolis. Minneapolis, MN. October 2-3, 2000: 226-253.

Furtan W.H., R.S. Gray, and J.J. Holzman. "Strategic Licensing Decisions and the Gains from Trade: The Case of Genetically Modified Wheat." Working Paper. University of Saskatchewan, Department of Agricultural Economics. 2002.

Janzen, Edward L., Jeremy W. Mattson, and William W. Wilson. "Wheat Characteristic Demand and Implications for Development of Genetically Modified Grains." Agribusiness and Applied Economic Report No. 469. Department of Agribusiness and Applied Economics. Fargo, ND. November 2001.

Kuntz, Grant M. "Transgenic Wheat: Potential Price Impacts for Canada's Wheat Export Market." Master's Thesis. University of Saskatchewan, Department of Agricultural Economics. 2001.

Monsanto. Extending Roundup Ready Benefits to Wheat. Monsanto Company, Wheat Industry Team, Bulletin #004065. St. Louis, MO. 2001.

North Dakota Extension Service. *Farm Management Guide: Projected 2003 Crop Budgets*, various regions. December 2002.

North Dakota Farm and Ranch Business Management Annual Reports, 2000 and 2001. North Dakota State Board for Vocational Education. Bismarck, ND.

Richard Lawrie Associates. Personal Communication. 95 Effra Road, Wimbledon, London. SW19 8PS.

Reuters News Service. “Top Italian Miller to Spurn Gene-modified Wheat.” 2/03/2003.

Taylor, Richard D., and Won W. Koo. “2002 Outlook of the U.S. and World Wheat Industries, 2001-2011.” Agribusiness & Applied Economics Report No. 486. Center for Agricultural Policy and Trade Studies. Department of Agribusiness and Applied Economics. NDSU. Fargo, ND. August 2002.

U.S. Department of Agriculture Economic and Statistics System website. http://usda.mannlib.cornell.edu/usda/usda.html

U.S. Wheat Associates. “Japan: U.S. ‘GM Wheat Market Assessment Team’ Report,” April 2001.

U.S. Wheat Associates. “Japan Millers: Update August 2001,” August 2001.

U.S. Wheat Associates. “Trade Policy Statement,” USW Board of Directors Meeting, July 2002.

Wilson, William W., Edward L. Janzen, Bruce L. Dahl, and Cheryl J. Wachenheim. “Issues in Development and Adoption of Genetically Modified (GM) Wheats.” Agribusiness and Applied Economic Report No. 509. Department of Agribusiness and Applied Economics. Fargo, ND. January 2003.

Wisner, Robert. “GMO Wheat: Its Potential Short-term Impacts on U.S. Wheat Export Markets and Prices.” Working Paper. Iowa State University. 2003.

Appendix

Table 1. Calculated Transportation Costs For Origin-Destination Routes

Origin	Manitoba	Sask	Alberta	B.C.	ND	OSR	WR
Destination	---------------------------------$/metric ton-------------------------------------						
Bangladesh	50.54	46.75	41.22	40.94	51.30	51.30	40.11
Chile	49.69	40.41	34.88	34.60	45.82	45.82	35.34
China	40.83	36.57	31.04	30.76	43.44	43.44	31.10
Colombia	46.01	46.26	40.73	40.45	34.11	34.11	23.88
D. Republic	43.70	44.91	39.38	39.10	28.80	28.80	23.45
Ecuador	52.76	35.36	29.83	29.55	39.46	39.46	27.10
Egypt	44.70	45.91	40.38	40.10	30.47	30.47	28.50
EU	43.61	43.61	40.53	40.25	27.20	27.20	28.05
Guatemala	45.01	45.26	39.73	39.45	27.86	27.86	22.88
Indonesia	46.76	46.48	40.95	40.67	51.59	51.59	46.07
Iran	50.54	62.06	68.01	73.59	39.06	39.06	35.76
Iraq	50.54	62.06	68.01	73.59	39.06	39.06	35.76
Israel	45.70	61.22	67.17	72.75	31.47	31.47	29.80
Japan	41.54	37.28	31.75	31.47	44.72	44.72	39.20
Jordan	45.70	61.22	67.17	72.75	31.47	31.47	29.80
S. Korea	39.61	35.35	29.82	29.54	42.54	42.54	37.02
Malaysia	46.50	41.83	36.30	36.02	47.77	47.77	42.25
Mexico	40.43	35.37	29.84	29.56	25.60	25.60	30.31
Nicaragua	45.01	45.26	39.73	39.45	27.86	27.86	22.88
Peru	53.22	36.36	30.83	30.55	40.46	40.46	28.10
Philippines	43.74	39.48	33.95	33.67	46.08	46.08	40.56
S. Lanka	50.54	61.06	67.01	72.59	39.06	39.06	34.76
Taiwan	41.60	37.34	31.81	31.53	44.00	44.00	38.48
Thailand	44.75	40.49	34.96	34.68	44.89	44.89	39.37
UAE	50.54	62.06	68.01	73.59	39.06	39.06	35.76
US	18.54	24.14	29.73	41.89	0.00	0.00	0.00
Venezuela	44.01	44.40	38.87	38.59	25.94	25.94	25.30
ROW	44.46	44.69	40.06	40.16	31.70	31.70	27.62