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CONTENTS

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Dragan Miljkovic

North Dakota State University
Department of Agribusiness and Applied Economics, 221G Morrill Hall
Fargo, ND, 58105-5636, U.S.A.
E-mail: Dragan.Miljkovic@ndsu.nodak.edu

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DUMPING ON AGRICULTURE: ARE THERE BIASES IN ANTIDUMPING REGULATIONS?

Kara M. Reynolds
American University
Department of Economics
Washington, DC 20016-8029 USA

ABSTRACT

The increase in antidumping activity over the past 10 years has sparked concern among some analysts that antidumping regulations may be biased toward imposing more protection on agricultural goods than other products. This research investigates these charges using a statistical and case study analysis of antidumping investigations conducted by the United States, Canada and Mexico between 1995 and 2003. I find some statistical evidence of bias in the outcomes of antidumping investigations involving agricultural goods compared to other products. The results suggest that this level of bias is higher in the United States when compared to both Canada and Mexico.

Keywords: agriculture trade, antidumping, import protection, regulatory bias.

As multilateral trade agreements have lowered tariffs and reduced quantitative trade restrictions across the world, the use of other regulatory tools has increased to fill the protection void. One of these forms of protection, antidumping regulations, has the potential to become one of the most significant barriers to world trade. Antidumping regulations allow industries to request that tariffs be imposed upon specific products from specific countries because these products are allegedly being sold at unfairly low prices and causing irreparable harm to the domestic industry. Once the domain of a handful of industrialized countries, the amount of antidumping trade protection across the world has steadily increased since the inclusion of the Antidumping Agreement in the last World Trade Organization (WTO) trade agreement. Ninety-eight WTO members filed 2,649 antidumping cases between 1995 and 2004, an almost 25 percent increase over the 10 years prior to this period.[1]

Agriculture-related products account for a small but fairly constant proportion of worldwide antidumping investigations each year; between 1995 and 2005 countries initiated antidumping investigations in 140 cases involving agricultural goods, or approximately 5

[1] These figures are calculated using data reported by the WTO and Zanardi (2002).

percent of the total number of investigations during this time period.[2] Of the investigations involving agricultural products, over half resulted in the imposition of duties. In some cases these duties dramatically limited exports of the targeted products. For example, in 2000 Mexico filed an antidumping case that eventually led to the imposition of a 10.2 percent antidumping tariff on U.S. exports of rice. The quantity of U.S. exports of rice to Mexico fell nearly 10 percent between 2000 and 2001 alone.

Many economists and industry analysts argue that current antidumping regulations could result in the imposition of higher levels of antidumping protection on agricultural products than other goods because of the unique characteristics of the industry. For example, because agriculture products are highly perishable, producers are more likely to be forced to sell products at distressed prices below their average total cost of production. This increases price volatility in the industry and makes it more likely that investigating authorities will find evidence of dumping under current regulations. Other characteristics of the agriculture industry have a similar potential to increase the level of antidumping protection above that of other industries.

Given the steady use of antidumping protection in the agriculture sector, and the dramatic impact these regulations can have on world trade of food products, it is important to understand to what degree antidumping regulations are biased toward imposing higher levels of protection against agricultural products compared to other goods. Although the WTO Antidumping Agreement supposedly harmonized global antidumping regulations, these regulations are not always applied consistently across countries.[3] Therefore, the level of this agricultural bias may vary across countries depending on idiosyncratic regulations.

This article analyzes the degree of agricultural bias in antidumping regulations by conducting a detailed analysis of the 45 agriculture-related antidumping investigations filed by the United States, Mexico and Canada between 1995 and 2003. Together these three countries accounted for 20.6 percent of all antidumping investigations and 42.8 percent of agriculture-related antidumping investigations initiated during the period.[4] I statistically compare the outcomes of the 45 antidumping investigations involving the agriculture industry to those investigations involving other industries during the period. I also conduct a comprehensive case study analysis of these investigations to determine what specific aspects of antidumping regulations may be causing an agriculture bias, and whether some governments tend to impose more protection upon food products than others. I find some statistical evidence of bias in the outcomes of antidumping investigations involving agricultural goods compared to other products. The results suggest that idiosyncratic regulations make the level of agriculture bias higher in the United States when compared to both Canada and Mexico.

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[2] I define the agricultural sector to include Sections I through IV of the Harmonized System of trade classification. These sections include raw and processed food products, including seafood, but exclude products such as lumber.

[3] One sign of the degree of inconsistency in antidumping regulations across countries is the number of trade disputes that have erupted over the use of antidumping. According to the list of disputes published by the WTO, 17 percent of trade disputes initiated at the WTO between 1995 and 2005 involved antidumping investigations; of these antidumping disputes, over 20 percent involved antidumping duties imposed upon agricultural products.

[4] I limited the analysis to cases involving the United States, Mexico and Canada in order to reduce the number of detailed case studies that had to be undertaken for the study. This sample does unfortunately restrict the degree of comparison I can make across all countries.

The remainder of the article proceeds as follows. In the next section, I provide an overview of the WTO Antidumping Agreement, focusing on those aspects of the Agreement that may result in higher levels of antidumping protection in the agricultural sector than others. This discussion also notes some key differences in antidumping procedures in the United States, Canada and Mexico which may impact the degree of agricultural bias across countries. The third section reviews the previous literature on agricultural bias in antidumping regulations, describing the theoretical reasons why current regulations may result in a bias. I present statistical and case study analyses of the level of agricultural bias in antidumping investigations conducted in North America in the fourth section, and present my conclusions in the final section.

ANTIDUMPING REGULATIONS

The current international Antidumping Agreement (the Agreement), which was included in the 1994 Uruguay Round Trade Agreement, allows countries to protect their domestic industries by imposing extra import duties on the products the country finds to have been dumped. Prior to imposing these tariffs the country must undertake a lengthy investigation to (1) show that dumping is taking place and calculate the extent of this dumping and (2) prove that the dumping is injuring the domestic industry. The Agreement provides guidelines as to how the investigation must be conducted and the subsequent antidumping duties imposed. The discussion below focuses on the aspects of the Agreement that I believe are of particular importance in the outcome of investigations involving agricultural goods.

Under the Agreement, antidumping petitions may be filed by or on behalf of a domestic industry. In order to have standing to file the petition, supporters of the petition must constitute more than 25 percent of domestic production of the like product and 50 percent of production of those producers that both support and oppose the petition. The agreement defines the domestic industry as producers of the “like” product, or the product identical to or, in the absence of an identical product, the products which have characteristics closely resembling those of the product under investigation.

The WTO antidumping agreement directs countries to calculate the antidumping margin or duty as the difference between the export price and the normal value of the product in the “ordinary course of trade.” Typically, the normal value is defined as the price set by the producer in their domestic market. Any sales made at prices below the producer's average cost of production over an extended period of time and in substantial quantities may be defined by the investigating authority as outside of the ordinary course of trade and be excluded from the calculation of normal value. Thus, antidumping regulations target both price discrimination and predatory pricing, or pricing below the average total cost of production. If there are insufficient sales in the domestic market, the investigating authority may use alternative definitions of normal value such as the price set by the producer in a representative third country market. Alternatively, investigating authorities may define the normal value as the producer's cost of production plus a built in margin for administrative expenses and profits, often referred to as a “constructed value.”

Investigating authorities are directed to collect price and cost information from each producer under investigation in order to calculate firm-specific dumping margins. The

Agreement stipulates that if producers fail to provide necessary information within a reasonable period, determinations may be made on the basis of the “facts available.” In cases where the number of producers is too large to make calculating individual dumping margins tractable, the authorities may limit their examination to a “reasonable number” of producers by sampling from the industry.

The Agreement specifies that governments must make injury determinations based upon an objective examination of the volume of dumped imports and the effect of these imports on domestic prices, as well as the impact of these imports on domestic producers. Importantly, it is not enough to show that the domestic industry has been injured; the government must prove a causal link between the dumped imports and the injury.

The Agreement requires investigating authorities to terminate all investigations immediately upon finding that the margin of dumping is *de minimis*, or less than two percent as a percentage of the export price, or that there is insufficient evidence that the dumped imports have caused injury to the domestic industry. The Agreement allows governments to terminate or suspend antidumping investigations if they reach an agreement with the exporting country, typically known as a suspension agreement, to revise its prices or limit its exports so that the injurious effect of the dumping is eliminated. If the investigating authorities make final affirmative determinations that the country under investigation has dumped products on the domestic market and these dumped imports have caused injury to the domestic industry then they may impose “permanent” antidumping duties on the products in question.[5]

Under the Agreement, countries have a great deal of latitude in the design of the antidumping investigation process. Both the United States and Canada have a bifurcated investigation procedure in which one agency determines the level of dumping and a second agency determines whether the dumping has caused or threatened to cause material injury to the domestic industry. In the United States, the International Trade Administration (ITA) of the Department of Commerce initiates the investigation, and the U.S. International Trade Commission (ITC) undertakes a preliminary investigation to determine whether there is sufficient evidence that dumped imports have injured the domestic industry to continue the investigation. If the ITC makes an affirmative decision, the ITA conducts a preliminary and then final investigation regarding the level of dumping by the country under investigation. The investigation then returns to the ITC for its final determination regarding injury. In Canada, the dumping margin and injury decisions are made by the Canadian Border Services Agency (CBSA) and Canadian International Trade Tribunal (CITT), respectively. In contrast, both the injury and dumping decision are undertaken by a single agency in Mexico, the Secretariat of Economy (SE), and released simultaneously.

Countries have other idiosyncratic regulations that may lead to the imposition of higher dumping duties in some countries than others. For example, the Agreement specifies that countries should calculate dumping margins either by comparing the weighted average export price to the weighted average normal value or by comparing export price to normal value on a transaction by transaction basis. The United States typically compares a weighted average normal value to individual export prices, which is also allowed for under the Agreement in

[5] Under the Agreement, countries must review antidumping orders every five years in “sunset reviews” to determine whether the imposition of the antidumping duty is still warranted, or if it is still necessary to counteract the dumping of products which is causing injury.

special circumstances. In this calculation, the United States assigns those export transactions with a negative dumping margin, or those sold above normal value, a zero dumping margin rather than a negative margin in a practice called zeroing. This practice has been criticized by a large number of economists as resulting in higher dumping margins and has been challenged at the WTO (Boltuck and Litan 1991).

REVIEW OF THE CURRENT LITERATURE

A number of authors have hypothesized that current antidumping regulations may result in the imposition of higher levels of protection on agricultural products than manufactured goods due to the unique characteristics of the agriculture industry. Specifically, antidumping duties may be higher in the agricultural sector because of the perishable nature of the product, the large number of producers in the industry, the high fixed costs of production, tremendous advances in agriculture productivity, and the cyclical nature of agricultural prices. The discussion below focuses on each of these characteristics in turn.

Using a theoretical model of dumping with seasonality and uncertainty, Hartigan (2000) illustrates that agricultural prices tend to be much more volatile than manufacturing good prices due to the uncertainty surrounding the level of output and the perishable nature of the product. Intuitively, because the short shelf life of agricultural products precludes holding inventories, producers are forced to accept whatever price the market will bear. At periods of peak production when supply is high, this price might be significantly below the producer's average cost of production. NFAPP (2000) makes a similar argument regarding the produce industry, pointing out that due to the perishable nature of produce producers are often forced to sell products at "distressed" prices, or those far below its variable cost of production. Price volatility and the tendency to sell at distressed prices could increase the dumping margin in three important ways. First, antidumping investigations involving agricultural products will tend to use a cost-based definition of normal value, a method which could result in the imposition of higher dumping duties when compared to other methods. Second, the distressed prices set by agricultural producers may be much further below average cost than the prices manufacturers typically set, thus resulting in larger dumping margins. Finally, the higher price volatility in the agricultural sector could lead to higher dumping margins when countries like the United States calculate the dumping margin by comparing a weighted average normal value to a transaction by transaction import price and use the zeroing method described above.[6]

Other analysts have argued that current antidumping regulations could bar agricultural producers taking part in antidumping investigations due to the perishable nature of their product. Specifically, NFAPP (2000) raises concerns over statutes governing the definition of "like" products. Because of the perishable nature of the product, many raw agricultural products are canned or processed in some other way. In cases involving processed food products, investigating authorities must decide whether to include growers of the raw

[6] Consider the example provided in Blonigen (2004). If a product has an export price above normal value by 20 percent half the time and below normal value by 20 percent for half the time, they would be assigned a dumping margin of 10 percent. However, a product with less volatile prices, who sells above normal value by 10 percent half the time and below normal value by 10 percent the other half will only be assigned a dumping margin of 5 percent.

agriculture input in the definition of the domestic industry. This could prevent agricultural producers from filing or taking part in an antidumping petition even though imports of processed food products have a significant impact on profit margins. If producers of raw agricultural inputs are materially injured due to imports of dumped processed food products, and investigating authorities exclude these growers from the definition of the industry, authorities may be less likely to find evidence of injury.

Hartigan (2000) notes that because of the large number of producers in the agriculture industry countries are more likely to use sampling techniques and calculate dumping margins based on only a subset of producers, which could result in less accurate and potentially higher duties than in the manufacturing sector. He also suggests that smaller agricultural producers may keep poor financial records compared to manufacturers, leading countries to calculate inaccurate and typically higher margins than deserved, particularly if they resort to using "facts available."

Economic theory states the producers should set price at marginal cost, not the average total cost of production. Under current antidumping regulations, however, countries calculate the dumping margin as the difference between the price and the average total cost of production. As Palmeter (1989) points out, agricultural producers tend to have extremely high fixed costs of production, particularly land costs. These high fixed costs of production will make the difference between the average total cost of production and the marginal cost of production much greater in the agricultural sector when compared to industries with lower fixed costs of production, potentially increasing the dumping margins in these industries.

Barichello (2002) hypothesizes that a country is more likely to find evidence of both dumping and injury of horticulture products than others because real producer prices in horticulture have trended downward due to improvements in technology and increased productivity. Firms slow to adopt the changes in technology are more likely to face losses. As a result, it is more likely that government investigators will find evidence of financial losses in the domestic industry, and because of lags in getting up to date cost data, the government is more likely to find evidence that prices are below cost. Barichello (2002) also notes that many agricultural commodities' prices fluctuate in cycles that often last more than the two or three years used in the government's calculation of injury and dumping. As a result, the government is almost guaranteed to find evidence of dumping and injury during periods of investigation that occur during low-points in the cycle if they fail to take this cyclical nature into account.

Many of the papers discussed above, including Palmeter (1989), NFAPP (2000), and Barichello (2002), include a discussion of selected antidumping investigations to illustrate their theoretical arguments that antidumping laws are biased against agricultural products. Blonigen (2004) instead conducts an empirical analysis of all U.S. antidumping investigations between 1980 and 2000 to determine whether higher dumping duties are imposed on agricultural products than others. The raw statistics from this sample indicate that the average dumping margin for agricultural products during this time was 64.1 percent compared to 38.8 percent for non-agricultural products. However, when investigations involving China are excluded from the sample, the average agricultural margin is lower than the average manufacturing margin. Blonigen's (2004) regression analysis rejects the hypothesis that the use of a cost-based normal value will result in higher dumping duties in the agricultural sector than others. However, the use of other methods of calculating normal value does seem to result in higher margins in the agricultural sector than others.

This article builds upon the current literature by more closely examining several of the assertions described above. Specifically, I first study whether investigating authorities utilize cost-based definitions of dumping margins and "facts available" more often in agriculture-related investigations than others. I then analyze whether the methods chosen or other characteristics of the agriculture sector result in the calculation of higher dumping margins in the agriculture sector when compared to others. I further investigate whether investigating authorities are more likely to find evidence of injury in agriculture-related investigations, thus imposing dumping duties. Finally, I study whether agriculture producers are prohibited from taking part in antidumping investigations due to current regulations governing the definition of the "like product." Throughout the analysis I attempt to discern whether the level of agriculture bias differs across countries due to idiosyncratic regulations by specifically analyzing case outcomes in the United States, Mexico and Canada. More details about these cases are provided in Reynolds (2006).

AN ANALYSIS OF AGRICULTURE BIAS IN ANTIDUMPING

As suggested above, the level of antidumping protection may be higher in agricultural industries compared to others because (1) investigating authorities are more likely to find evidence that foreign producers have dumped products by larger margins and/or (2) investigating authorities are more likely to find evidence that these dumped imports have caused injury to domestic producers. Both of these possibilities will be considered in the analysis below. However, it is important to note that the analysis may be tainted by two sources of sample selection bias. In particular, if the probability that an antidumping investigation will successfully result in the imposition of tariffs is higher in agricultural industries compared to others, one would expect more petitions to be filed by agricultural producers when compared to manufacturers because the expected benefits of the petitions are so much higher. Likewise, foreign agricultural producers may be more likely than manufacturers to seek a settlement with investigating authorities if the probability that the investigation will eventually result in duties is higher in agriculture. The discussion below first considers both of these potential sources of selection bias. I then present an analysis of the dumping margin and injury determinations.

The Initiation of Antidumping Investigations

Between 1995 and 2003, U.S. agricultural producers and food manufacturers filed 25 antidumping petitions against foreign producers, or 7.6 percent of all antidumping petitions filed by U.S. producers. As noted in Carter and Gunning-Trant (2003), the agriculture and food processing sectors account for only 2.6 percent of U.S. GDP and less than five percent of U.S. imports, thus agriculture producers file a disproportionate share of antidumping petitions. The leading targets of antidumping petitions filed by U.S. agricultural industries include Canada, Mexico, Chile and China, as illustrated in figure 1. Of these investigations, 36 percent involved raw agricultural products while the remaining 64 percent involved processed food products of one degree or another.[7]

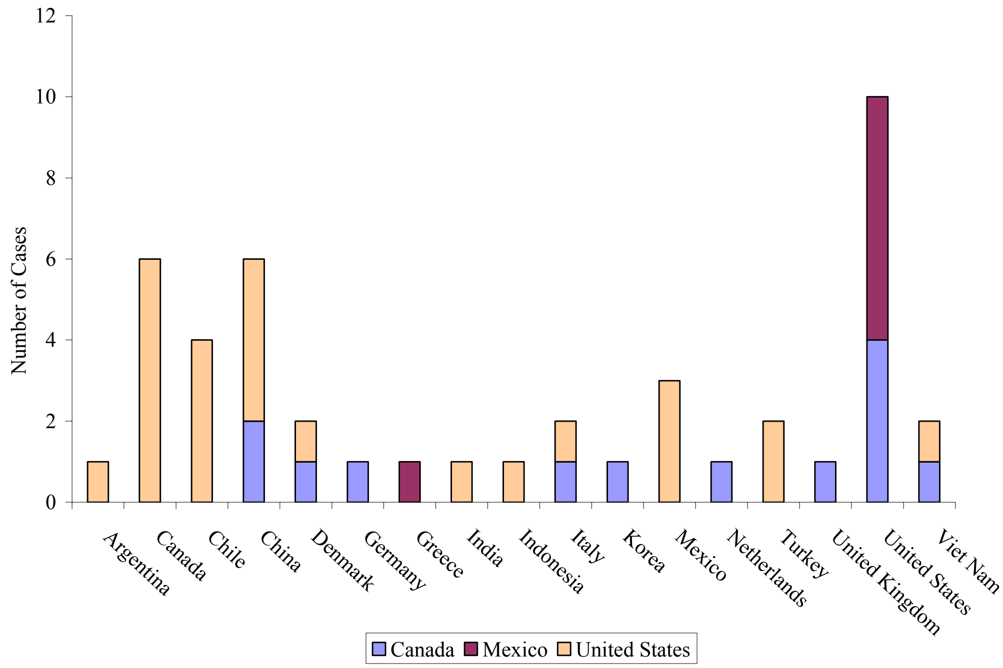

Figure 1. Targets of the antidumping cases filed by the North American agriculture industry, 1995-2003.

Agriculture products accounted for an even greater share of Canadian and Mexican antidumping investigations during this time period. Canada initiated 13 agriculture-related antidumping investigations, accounting for 9.5 percent of the country's total antidumping activity. Mexico initiated seven agriculture-related antidumping investigations, or 10.8 percent of the country's total antidumping activity. As illustrated in figure 1, the United States was by far the leading target of agriculture-related antidumping investigations by Canada and Mexico.

Although this disproportionate share of antidumping petitions in the agriculture industry could be an indication of an agricultural bias in antidumping regulations, virtually all of the investigations initiated by these three countries were against their North American Free Trade Agreement (NAFTA) partners. Therefore the high level of antidumping activity in the agriculture sector could simply be an indication of the high degree of conflict in the North American agriculture industry.

Feinberg and Reynolds (2006) finds significant evidence that industries in importing countries may file antidumping petitions against a particular country in order to retaliate against that country for previous antidumping petitions against the importing country. It is interesting to note that an analysis of antidumping investigations involving North American agricultural producers suggests that retaliation is often a motivating factor in the decision to

[7] The degree of processing varied considerably among those goods investigated, ranging from honey, seafood and meat products to pasta, cookies and jarred baby food.

file these petitions. For example, U.S. growers of greenhouse tomatoes filed an antidumping petition against Canadian growers in March of 2001. Six months later, just days before the United States imposed preliminary antidumping duties against Canadian tomato imports, the Canadian tomato growers filed a retaliatory antidumping petition against all U.S. tomato growers.

Other examples suggest that antidumping petitions may be filed not in retaliation for other antidumping actions, but rather to impose pressure on the exporting government to change other trade regulations. For example, Canadian producers of refined sugar filed an antidumping petition against U.S. producers in 1995 shortly after the United States increased restrictions on Canadian sugar imports. U.S. producers claimed that Canada was simply retaliating against the recent restrictions, and a Canadian adviser to the sugar industry noted that they hoped the antidumping petition would put pressure on the U.S. government to relax the restrictions (Urquhart 1995). Similarly, U.S. pork producers argued that the 2003 antidumping petition filed by Mexican producers was an attempt to compel the United States to agree to reverse NAFTA's market access provisions for Mexican pork. Based on these examples, 30 percent of the antidumping investigations initiated against U.S. producers by its NAFTA partners were in retaliation for some U.S. policy action.

Settlement of Antidumping Investigations

As noted in table 1, four percent of antidumping petitions filed by U.S. agricultural producers and 14 percent of petitions filed by Mexican growers were suspended prior to governments reaching final determinations in the investigations. Recall from above that the WTO Antidumping Agreement allows governments to suspend an antidumping investigation if they reach an agreement with the exporting country to revise its prices or limit its exports so that the injurious effect of the dumping is eliminated. This is the method that the United States used to resolve the antidumping petition filed by U.S. tomato growers against Mexican imports, and the method that the Mexican government used to resolve the antidumping petition filed by Mexican apple growers against U.S. imports. Petitions involving agricultural products appear to be slightly more likely to be suspended than those involving other industries in the United States and Mexico; only 3 percent of cases filed by other U.S. industries were suspended, and the U.S.-Mexican suspension agreement involving apples was the only petition filed by Mexico that resulted in a suspension agreement. Canada reached suspension agreements in three investigations, none of which were agriculture-related.

In addition to the suspended investigations, 8 percent of petitions filed by U.S. agricultural producers were terminated by the industry prior to the government reaching a final determination. Industries sometimes choose to withdraw their petition or request that the investigation be terminated, although unlike the clear benefits from a suspension agreement it is often less clear why industries would choose to terminate an investigation. In the case of one of the two antidumping petitions terminated by U.S. agricultural industries, the hazelnut industry reached a private agreement with Turkish hazelnut producers that included funding for a U.S./Turkey hazelnut marketing program and access to the Turkish gene repository for hazelnut trees. U.S. mussel producers also withdrew their petition after domestic mussel prices began to increase shortly after the preliminary imposition of antidumping duties. Based on this small sample, it appears that antidumping petitions involving agricultural industries are also more likely to be terminated by the industries in the United States; only 3.7 percent of petitions filed by other industries were terminated prior to a government determination.[8] However, none of the three cases terminated in Mexico during this time period involved agricultural products.

Table 1. Outcome of North American Antidumping Investigations, 1995-2003

	Agriculture-Related Investigations					
	United States		Canada		Mexico	
	Number	Share	Number	Share	Number	Share
Affirmative	15	60.0	9	69.2	4	57.1
Negative	7	28.0	4	30.7	1	14.3
Suspended	1	4.0	0	0.0	1	14.3
Terminated	2	8.0	0	0.0	0	0.0
In Progress	0	0.0	0	0.0	1	14.3
Total	25	100.0	13	100.0	7	100.0
	All Antidumping Investigations					
	United States		Canada		Mexico	
	Number	Share	Number	Share	Number	Share
Affirmative	152	46.2	83	60.6	31	47.7
Negative	154	46.8	51	37.2	17	26.2
Suspended	10	3.0	3	2.2	1	1.5
Terminated	13	3.9	0	0.0	3	4.6
In Progress	0.0	0.0	0	0.0	13	20.0
Total	329	100.0	137	100.0	65	100.0

The Level of Dumping Duties

As discussed above, analysts have hypothesized that antidumping duties will be higher in the agriculture sector because producers are often forced to sell their perishable products at distressed prices below their average cost of production. Moreover, the difference between the average cost of production and the marginal cost of production, or the profit maximizing price, is expected to be higher in the agriculture sector because of the high fixed costs of production. Both explanations suggest that investigating authorities will choose to use the constructed value method to calculate normal value more often in investigations involving agricultural products than other investigations; this method defines the normal value as the average cost of production rather than the price set by the producers in their domestic market.

The methods used to calculate normal value in the antidumping investigations involving North American food producers between 1995 and 2003, as well as the average "all others" final antidumping duties imposed in these investigations, are presented in table 2.[9] Together,

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[8] These statistics exclude those petitions that were withdrawn only to be re-filed a short time later with additional information.

[9] Because it is often impossible to collect data from all firms within an industry, governments typically set firm-specific margins for the largest producers in the industry and an "all others" rate. Most countries typically define this "all others" rate as the weighted average of the margins imposed on individual firms specifically considered in the investigation. Note that table 2 excludes those investigations that were terminated or suspended prior to the determination of the final dumping margin.

the three countries considered in this research used the primary method recommended under the WTO Antidumping Agreement, the prices charged by firms under investigation in their domestic market, to calculate the normal value in 36 percent of all antidumping investigations involving food products. Note that under this method all sales made below the firm's average cost of production are excluded from the calculation. As a result, the United States, Mexico and Canada supplemented the home market prices with constructed values in 70 percent of these investigations.[10] The United States used prices set by the firms under investigation in a third-country market to calculate normal value in slightly over 16 percent of their agriculture-related investigations. Together, the United States, Mexico and Canada relied exclusively on the constructed-value method of calculation in only 14 percent of cases. This proportion is approximately equal to the proportion of investigations using constructed value in the full sample of investigations. For example, of those U.S. investigations that resulted in the imposition of antidumping duties between 1995 and 2003, twelve percent used the constructed value method.

Table 2. Method of normal value calculation and average final dumping margin in agriculture-related investigations, 1995-2003

	U.S. Investigations		Canadian Investigations		Mexican Investigations	
	Number	Margin	Number	Margin	Number	Margin
Home Market	7	17.9	4	46.0	2	17.9
w/ Constructed Value	7	17.9	2	52.5	0	n.a
Third-Country Market	3	7.5	0	n.a	0	n.a
Non-Market Economy	5	139.9	3	64.6	0	n.a
Constructed Value	3	65.4	1	27.0	2	47.4
w/ “Adverse Facts”	0	n.a.	0	n.a	1	46.6
“Adverse Facts”	0	n.a.	5	64.3	1	10.2
All	18	60.2	13	55.8	5	28.1

Note that as agriculture analysts have hypothesized, the use of constructed value does seem to result in higher dumping margins. For example, the average final dumping margin determination in investigations involving U.S. food processors was 29.4 percent in those investigations which solely used domestic prices to calculate normal value, but 87.3 percent in those investigations that used constructed value. The average margin in investigations using constructed value in Mexico and Canada was also higher that the average in investigations solely using domestic prices. But as indicated in the discussion above there is no strong evidence that the constructed value method is used more often in agriculture-related investigations than others.

Many country’s antidumping regulations include special provisions to calculate normal value in investigations involving non-market economies such as China and Vietnam. For example, the United States calculates a constructed value by valuing the factors of production of each non-market economy firm at market prices from a surrogate market economy. This surrogate market economy must produce the product in question and be at a similar level of

[10] For example, in the 2001 investigation into the dumping of greenhouse tomatoes by Canadian producers, the United States used constructed value to calculate the normal value for specific grades and sizes of tomatoes when there were insufficient quantities of sales of these products made above the firm's average cost of production to calculate the normal value using the prices set in the Canadian market.

development to the non-market economy. Nearly 30 percent of the U.S. investigations and 23 percent of the Canadian investigations targeting a food product involved non-market economies.

The average dumping margin set by the United States in investigations involving non-market economies is statistically significantly higher than other investigations; the average dumping margin in a non-market economy case was 139.9 percent compared to 27.1 percent in other investigations. Similarly, the dumping margins in non-market economy investigations in Canada averaged 64.6 percent compared to 57.37 percent for all other food-related investigations. This bias may be due to pricing decisions in the non-market economies, or the bias may be due to the calculation method itself which is often controversial.[11] There is no evidence that this non-market economy bias is unique to the agriculture sector; the average antidumping duty for all non-market economy investigations in the United States during this time period was 140.8 percent compared to 45.4 percent for all other investigations.

Under the WTO Agreement, if firms under investigation refuse or fail to provide information requested by government investigators within a "reasonable" period of time then governments may make dumping margin determinations on the basis of "facts available." Often the "facts available" are the dumping margins requested by domestic firms in their initial petition for antidumping protection, although investigators may also use other outside information. "Facts available" are often used to set dumping margins for specific firms, but these (typically higher) dumping margins are not used to calculate the "all others" dumping margin rate. In other cases "facts available" are used to determine dumping margins for all or most producers under investigation.

Recall that some analysts have worried that "facts available" may be used more often in agriculture investigations because the smaller producers will tend to keep poor financial records. In fact, "facts available" were used in 33 percent of the dumping margin determinations involving food products in North America, including all of the U.S. investigations involving non-market economies. For example, in the 1997 investigation of apple imports from the United States, Mexico initially dismissed all information provided by U.S. producers because the information did not match the information provided by Mexican importers. The preliminary dumping margin was determined based on the margin requested by Mexican apple growers.[12] Similarly, Mexican investigators used adverse facts available to determine the dumping margin for all rice producers not specifically included in the initial investigation because one U.S. firm reported that they did not ship any rice to Mexico during the investigation period. There is some evidence that "facts available" are used more often in agricultural cases compared to other cases. For example, Canadian investigators used "facts available" to calculate dumping margins for 62 percent of the non-food related firms considered between 1995 and 2003, but 95 percent of the food-related firms.

The above discussion suggests that certain methods of calculation may result in higher dumping margins than others and some of these methods, particularly "facts available," may

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[11] For example, the Department of Commerce chose to use Bangladesh as the surrogate economy to price the cost of fish in Vietnam during the 2002 antidumping investigation into imports of frozen fish fillets from Vietnam, despite the fact that Vietnamese producers argued throughout the investigation that prices were much higher in Bangladesh than in Vietnam.

[12] Further investigation revealed that Mexican importers routinely generated false invoices in order to avoid import duties. Thus, Mexico later included data from U.S. producers to calculate the normal value.

be used more often in agriculture-related investigations when compared to others. However, there is little statistical evidence that dumping margins are higher in those investigations involving food products when compared to others.[13] Statistically, the mean and variance of the final duty determination in North American antidumping investigations was the same regardless of whether or not the investigation involved a food product or, even more specifically, a raw agricultural product.[14] The average final dumping margin set by the United States, Mexico and Canada in non-agriculture related investigations between 1995 and 2003 was 55.34 percent, compared to 54.08 percent in all food-product investigations and 71.73 percent in investigations involving raw agricultural goods. Although the histogram of the distribution of the final dumping margin determinations presented in figure 2 seems to indicate that there is a disproportionate share of investigations involving raw agricultural goods with antidumping duties over 180 percent, in fact a chi-square goodness of fit test fails to reject the null hypothesis that the distributions of agriculture and non-agriculture dumping duties are identical. These results seem to reject the hypothesis that current antidumping regulations result in the imposition of higher duties on agricultural goods than other products.

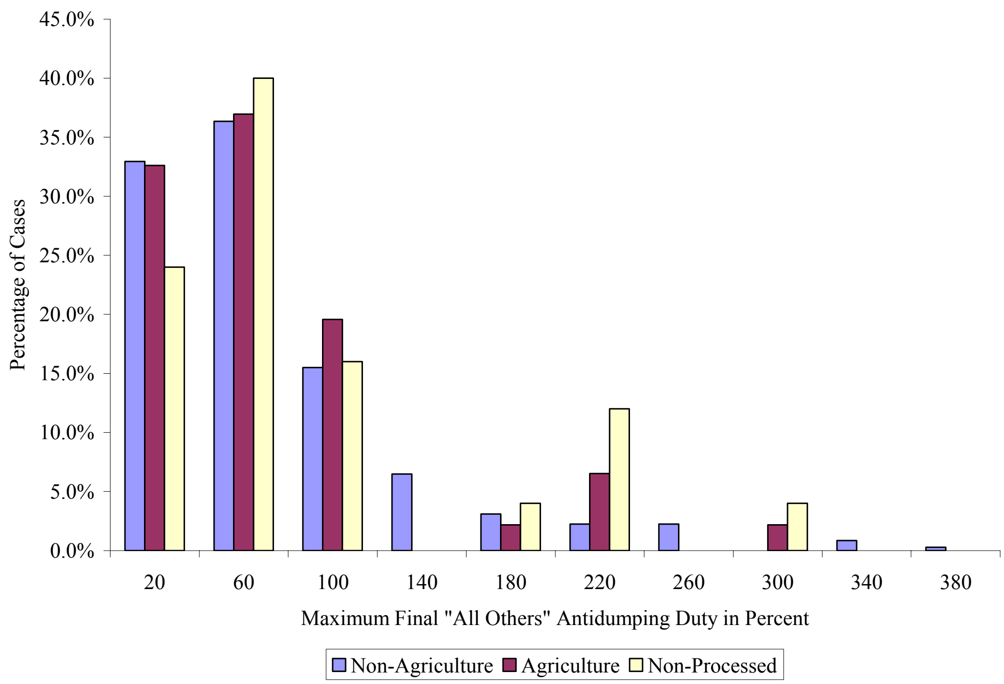

Figure 2. Distribution of final antidumping duties: North American investigations.

There is also no statistical evidence that idiosyncratic regulations in specific countries have led to a higher level of agricultural bias in some countries when compared to others. Figure 3 presents the average antidumping duties in non-agriculture, agriculture-related and

[13] Please see the statistical appendix for a description of statistical tests used and their results.

[14] These calculations are based on all final dumping margin determinations, not the final duties imposed. In other words, the calculations include dumping margin determinations in those investigations in which the government eventually found no evidence of injury and dismissed the case without imposing duties.

raw agriculture product investigations in the United States, Canada and Mexico. In general, the United States has higher average dumping margins in all three categories when compared to both Canada and Mexico. Specifically, the average dumping margin on all products was 59.0 percent in the United States, 46.91 percent in Canada and 43.61 percent in Mexico. Although the difference in average dumping margins between non-agricultural goods and raw agricultural products was much higher in the United States than in Canada and Mexico, statistical tests fail to reject the null hypothesis that the margins were the same across all categories of goods. Antidumping duties imposed upon agricultural products in Mexico were statistically significantly *lower* than those imposed upon other products.

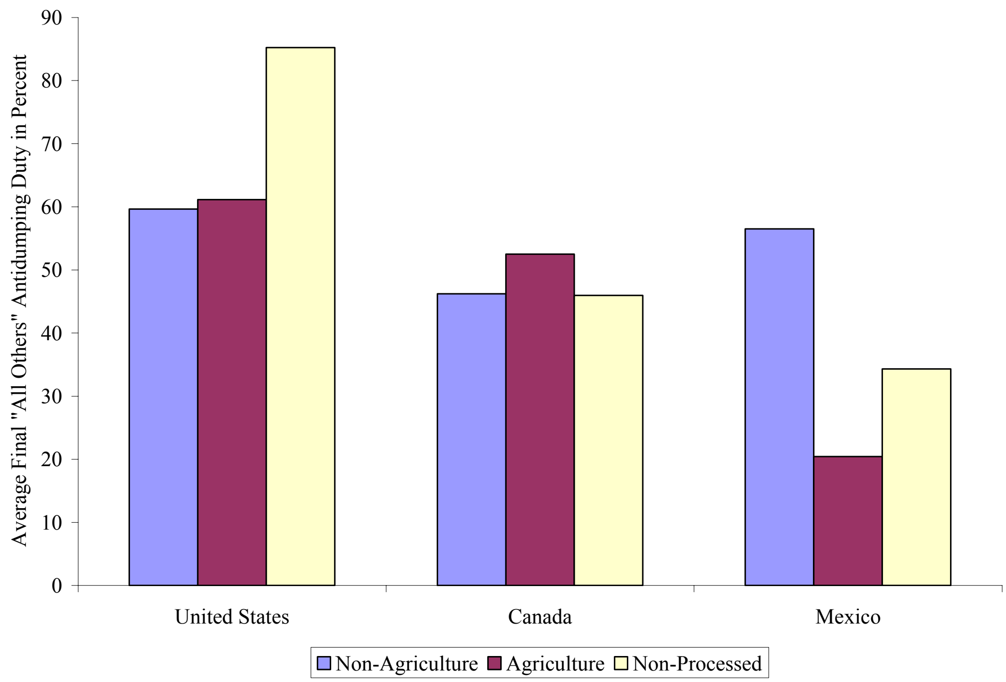

Figure 3. Average of final antidumping duties: North American investigations.

The Decision to Impose the Duties

Although the duties may not be higher, statistical analysis does provide some evidence that antidumping petitions involving agricultural products are more likely to result in the imposition of duties than investigations involving other industries. Excluding those cases that were terminated or suspended prior to a final government decision, 70 percent of the agriculture-related antidumping investigations initiated by the United States, Mexico and Canada successfully resulted in the imposition of duties compared to only 54.5 percent of all investigations initiated by the three countries. A statistical test rejects the hypothesis that the success rate in the agricultural sector is the same as that in the full sample of petitions, suggesting that agriculture-related investigations do more often result in duties than other investigations.

Further analysis suggests that the level of bias may differ across the three countries. As illustrated in table 1, 68.2 percent of U.S. agriculture-related antidumping petitions reaching a final government determination successfully resulted in the imposition of antidumping duties, compared to only 49.7 percent of all antidumping petitions filed by U.S. industries. In Canada, the comparable success rates were 69.2 percent for agriculture-related petitions and 61.9 percent for all petitions. In Mexico, the success rates were 80.0 percent for agriculture-related petitions and 64.6 percent for all petitions. Of the three countries, however, only the United States proves to have a statistically-significant higher success rate in agriculture-related investigations when compared to the full sample.

The rate of affirmative determinations at the preliminary injury and the dumping margin determination stage are virtually identical for both agriculture and non-agriculture petitions in the United States.[15] The apparent discrepancy in U.S. success rates between agriculture and non-agriculture related petitions must occur in the final injury determination.

Almost all of the theoretical arguments described above argue that the dumping margin determination will be higher in the agriculture sector when compared to other sectors, not that the likelihood of finding evidence of material injury will be higher. But because the level of the dumping margin is taken into account in the injury determination, a higher dumping margin determination could lead to a higher affirmative injury determination rate in the agricultural sector when compared to other sectors. Recall that while not statistically significant, average agricultural dumping margins were higher in the United States when compared to other sectors; the average duty on non-processed agricultural products was 85.2 percent compared to 61.1 percent for all agricultural products and 59.6 percent for non-agricultural products.

The higher success rate could also be caused by other U.S. antidumping investigation procedures. Barichello (2002) notes that many agricultural commodities' prices fluctuate in cycles that last more than the two or three years used in the government's calculation of injury. As a result, he argues that the government is almost guaranteed to find evidence of injury during periods of investigation that occur during low-points in the cycle if they fail to take this cyclical behavior into account.

Recall that some analysts have raised concerns that antidumping regulations may be inherently unfair to producers of raw agricultural products if these producers are prohibited from taking part in antidumping actions against imports of processed agricultural products due to the investigating authority's definition of the "like product." This definition could also impact the injury determination if raw producers are materially injured by imports of the processed food product but excluded from the investigation.

An analysis of the agriculture-related investigations in North America suggests that WTO rules on this matter are subject to wide interpretation and the restrictiveness of "like product" definition can vary significantly across countries. For example, in the United States the ITC includes growers in the definition of "like product" only if the processed product is produced from the raw product in a single continuous line of production and there is a "substantial coincidence" of economic interests between growers and processors. As a result of this definition, growers are typically excluded from the definition of the domestic industry and

[15] Approximately 20 percent of the U.S. antidumping petitions considered in this article were terminated after the ITC made a negative preliminary injury determination. The ITA almost always finds evidence that the imports under investigation have been dumped or sold at less than normal value.

these producers are prevented from participating in the antidumping investigations. Of the 16 antidumping investigations involving processed food products in the United States between 1995 and 2003, the ITC included growers, or the producers of the raw agricultural input, in only two--honey in which the domestic industry was defined as beekeepers and honey packers and frozen raspberries. The list of investigations where growers were excluded included hazelnuts, many fresh seafood products, and preserved mushrooms.

In contrast, Mexico typically uses a much broader definition of the like-industry. Mexico included cattle producers in the definition of the domestic industry producing beef products, and allowed hog producers to file an antidumping petition against U.S. imports of pork products. Mexico also allowed its domestic sugar industry to file an antidumping petition against U.S. imports of high-fructose corn syrup (HFCS), a corn-based sweetener. Although U.S. producers argued before a WTO dispute settlement panel that sugar could not be defined as a “like product” to HFCS, the WTO ruled that sugar producers should be allowed to request antidumping protection from HFCS imports. U.S. regulations typically result in much narrower definition of “like product” than antidumping procedures in Mexico. However, there is not enough data to determine whether the scope of the “like product” definition has a statistical impact on the likelihood of an affirmative injury determination.

Conclusion

Agriculture analysts have hypothesized that antidumping regulations are biased toward imposing more protection on agricultural goods than others due to unique characteristics in the industry such as the perishable-nature of the product. This article finds little statistical evidence that antidumping duty determinations are higher in the agricultural sector when compared to other industries. However, there is evidence that antidumping duties are more often imposed upon agricultural products than other products. In other words, investigations involving agricultural products more often result in the imposition of duties than those involving other products. The bias is particularly pronounced in the United States. Nearly 70 percent of agriculture-related antidumping investigations in the United States resulted in the imposition of antidumping duties compared to only 50 percent of all antidumping petitions filed by U.S. industries.

Because the sample considered in this research was limited to those investigations undertaken in North America, it is impossible to make generalizations regarding the level of agriculture-bias in the antidumping procedures in other countries. The analysis suggests, however, that differences in country-specific antidumping regulations may cause the level of agricultural bias to be higher in some countries when compared to others. Given these results, government officials should consider whether food producers could benefit from changes to the WTO Antidumping Agreement that further harmonize antidumping regulations and eliminate potential sources of agriculture bias.

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STATISTICAL APPENDIX

Success Rates of Antidumping Investigations and Distribution of Duties

I compare the success rates of agriculture-related antidumping investigations to all antidumping investigations using the test statistic:

$$\chi^2 = \sum_{b=1}^{B} \frac{(N_{bo} - N_{be})^2}{N_{be}}. \tag{1}$$

In this equation, if b equals 1 N_o is the number of successful agriculture petitions and N_e is the number of successful petitions that would be predicted by the percentage of successful petitions in the full-sample. Similarly, if b equals 2, N_o and N_e are the observed and expected number of unsuccessful petitions. The test-statistic has a chi-squared distribution with one degree of freedom, thus the five percent critical value is 3.84 and the 10 percent critical value is 2.71. The test statistic for the full sample is 3.87, thus I reject the hypothesis that success rates are the same in the agriculture industry compared to the full sample. The test statistics for the Mexican, Canadian and U.S. sub-samples are 0.51, 0.29, and 3.01 respectively.

I also compare the distribution of antidumping duties in agriculture-related investigations to non-agriculture related investigations using the above test statistic. In this case, b indexes the range of antidumping duties under consideration, and N_o and N_e are the observed and expected number of cases with antidumping duties within that range. The test statistic has a chi-squared distribution with $B-1$ degrees of freedom, thus for the nine bins considered in this research the five percent critical value is 15.51. The test statistic comparing the distribution of North American agriculture-related antidumping duties to non-agriculture related antidumping duties is 8.88, while the test statistic comparing the distribution of antidumping duties on non-processed agriculture products to non-agriculture related antidumping duties is 13.77.

Means of Antidumping Duties

I compare the means of antidumping duties across sectors using the t statistic:

$$t = \frac{\mu_1 - \mu_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}} \tag{2}$$

where μ_1 and σ_1 are the mean and standard deviation in sector one and μ_2 and σ_2 are the mean and standard deviation in sector two. N_1 and N_2 are the number of observations in sectors one and two respectively. The test statistic has the student-t distribution with the degrees of freedom defined by:

$$df = \frac{(\frac{\sigma_1^2}{N_1} + \frac{\sigma_1^2}{N_1})^2}{(\frac{\sigma_1^2}{N_1})^2 / (N_1 - 1) + (\frac{\sigma_2^2}{N_2})^2 / (N_2 - 1)}. \tag{3}$$

The test statistics and five percent critical values are listed in table 3.

Variances of Antidumping Duties

I compare the variances of antidumping duties across sectors using the F statistic:

$$F = \frac{\sigma_1^2}{\sigma_2^2} \tag{4}$$

where σ_1 and σ_2 are the standard deviations in sectors one and two, respectively. The statistic has the $F(N_1,N_2,\alpha)$ distribution, where N_1 and N_2 are the number of observations in sectors one and two respectively and α is the significance level of the test. The test statistic comparing the variance of North American non-agriculture related antidumping duties to agriculture-related antidumping duties is 1.08, while the test statistic comparing the variance of non-agriculture related antidumping duties to duties on non-processed agricultural goods is 1.41. The respective five percent critical values for the two tests are 1.81 and 1.94, respectively.

Table 3. Chi-squared test statistics and critical values comparing average antidumping duties across countries and products

Country	Group 1	Group 2	Test Statistic	Critical Value
All Three	Non-Agriculture	All Food	-0.13	2.00
All Three	Non-Agriculture	Non-Processed	1.07	1.70
United States	Non-Agriculture	All Food	0.09	2.04
United States	Non-Agriculture	Non-Processed	1.18	2.11
Canada	Non-Agriculture	All Food	0.98	2.06
Canada	Non-Agriculture	Non-Processed	-0.02	2.45
Mexico	Non-Agriculture	All Food	-2.86	2.11

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APPROACHES TO MEASURING THE EFFECTS OF TRADE AGREEMENTS

David Abler*

Department of Agricultural, Environmental and Regional Economics and Demography; Penn State University, State College, PA USA

"Ask five economists and you'll get five different answers – six if one went to Harvard."
Edgar R. Fiedler

ABSTRACT

In measuring the effects of trade agreements, the problem for economists is usually not a lack of answers but an abundance of them. Economists have developed a variety of approaches to analyzing trade agreements that often give very different results. Such conflicting results can create confusion among policy-makers and the general public and undermine the credibility of applied trade policy analysis. This paper argues that the use of multiple modeling approaches to answer the same question in applied trade policy analysis is almost always unwise. Instead, a single modeling approach should be chosen that is most appropriate for the problem at hand. This paper lays out criteria for choosing among modeling approaches. The paper describes the key approaches in the economic literature to measuring the effects of trade agreements, with a focus on their relative strengths and weaknesses and on the situations for which each modeling approach is most appropriate.

Keywords: trade, econometric, simulation, partial equilibrium, CGE.

INTRODUCTION

In measuring the effects of trade agreements, the problem for economists is usually not a lack of answers but rather an abundance of them. Economists have developed a variety of approaches to analyzing trade agreements that often give very different results. To an

* David Abler: Email: dave@bythenumbers.info; Phone: (814) 863-8630; 702 Windsor Court; State College, PA 16801

economist these discrepancies may be acceptable or even welcome because they can lead to insights as to why results differ from one modeling approach to another. However, among policy-makers and the general public, conflicting results can create confusion and undermine the credibility of applied trade policy analysis (Gohin and Moschini, 2004).

For example, recent estimates of the annual gains in welfare to developing countries from complete merchandise trade liberalization using computable general equilibrium (CGE) models range from $22 billion (Hertel and Keeney, 2006) to $128 billion (Anderson, Martin and van der Mensbrugghe, 2006). And estimates of changes in agricultural production and trade flows from these two models (as well as other CGE models) are generally significantly greater than those from partial equilibrium (PE) models such as the FAPRI model (FAPRI, 2002).

Conflicting estimates of the effects of trade agreements arise for multiple reasons. In some cases they reflect genuine uncertainty within the economics profession about the ways in which international trade may impact an economy and the magnitude of these impacts. The impacts of trade on productivity and technological change are good cases in point (Feenstra, 2004; Trefler, 2004). Another good case in point involves the values to assign to key parameters in economic models of trade, such as Armington elasticities of substitution, for which the knowledge base is weak (Hertel et al., 2007). These sources of uncertainty are not easily glossed over and ultimately the only remedy is additional empirical research.

In other cases conflicting estimates reflect the use of multiple modeling approaches to answer the same question. Estimates often differ in sign—that is, who gains and who loses from a trade agreement—and significant differences in the magnitudes of estimated gains and losses are also common (Gohin and Moschini, 2004). For example, Tokarick (2003) compares estimated impacts of agricultural trade liberalization using a PE model that he developed with those using the GTAP (Global Trade Analysis Project) CGE model (Hertel, 1997). Tokarick's PE model is similar in structure to many other PE models, while the GTAP model is the most widely used CGE model. His results from both models indicate agricultural trade liberalization increases social welfare in the EU, US, and Japan, but the magnitudes of the gains differ substantially between the two models. For the EU, social welfare gains are nearly three times greater with the CGE model than with the PE model. For Japan, they are over six times greater with the CGE model. On the other hand, social welfare gains for the US are only about half as large with the CGE model as with the PE model.

The thesis of this paper is that the use of multiple modeling approaches to answer the same question in applied trade policy analysis is almost always unwise. For the sake of clarity in trade policy deliberations, a single modeling approach should be chosen that is most appropriate for the problem at hand.

The objective of this paper is to develop criteria for choosing among modeling approaches. This paper describes the key approaches in the economic literature to measuring the effects of trade agreements, with a focus on their relative strengths and weaknesses and on the situations for which each modeling approach is most appropriate.

This paper focuses on modeling approaches, not on specific models. Thus the paper discusses CGE modeling as one approach but not the GTAP model in particular. A specific model may or may not show a modeling approach in the best light. While the GTAP model is exemplary of the best in CGE modeling, there are many models that are poor representatives of their respective approaches. For instance, the SWOPSIM (Static World Policy Simulation) model, an early partial equilibrium model developed by the US Department of Agriculture that was used in many agricultural trade policy analyses, is inconsistent with economic theory in several important respects and is weak in representing food processing and marketing activities (Peterson, Hertel and Stout, 1994). However, most of these limitations are not inherent to partial equilibrium modeling in general, and indeed there are more recent partial equilibrium models that have remedied most of SWOPSIM's deficiencies.

CHOOSING AMONG MODELING APPROACHES

In choosing among modeling approaches, one may ask "Which approach is the best?" This is fundamentally the wrong question. Instead, it is better to ask "Which approach is the best to answer the questions that I have?" No single model can fully capture all the possible impacts of a complex trade agreement. Analysts must weigh the desire for broad sectoral, product, policy, and country coverage with the need for detailed and accurate coverage of particular markets and policies (Westhoff et al., 2004). An economic model is a rough approximation to the real world rather than an exact characterization, and must ultimately be judged on the degree to which it answers the questions it was designed to answer (Boland, 1989). As Anania (2001) argues, one reason why many models are less than satisfactory is that they were built for a specific purpose, such as medium-term market projections, and then used for another purpose without any modifications to their basic structure.

While it may seem obvious to recommend the approach most likely to answer the questions being asked, in practice other criteria often come into play. For example, the modeling approach that an analyst, or the analyst's organization, is most familiar with may be chosen even when it is not the most appropriate. This takes advantage of specialized skills within an organization but at the cost of using a model potentially ill-suited to the problem at hand. Along the same lines, the modeling approach in which an organization has invested the most resources may be used even when there are other, more appropriate approaches. This can occur when an organization has invested a large amount of money in a particular model and administrators are under pressure to demonstrate that the model is being used. Alternatively, a modeling approach may be chosen simply because it is intellectually fashionable at the moment. Economics, like every other human endeavor, is subject to fashion trends and fads (Sunstein, 2001). A good example from agricultural economics is the "translog dissertation" days of the 1970s and 1980s, when a large number of Ph.D. dissertations were written that estimated cost or profit functions and applied the results to one policy problem or another.

Time constraints within an organization can also affect the choice of modeling approach, and can force a trade-off between completeness and complexity in modeling. When an analyst is expected to have results ready within a few days, deadline pressure almost ensures that the approach taken will be a relatively simple variation on the one the analyst is most familiar with. When the deadline is several months away, an organization has more time to explore alternative approaches and if necessary acquire (through training, hiring, or outsourcing) the skills required to implement the most suitable approach.

The modeling approach need not be quantitative. Perhaps a qualitative analysis using economic theory would be sufficient, or perhaps the answer is intuitively obvious to experts in the area. In many cases, though, only a quantitative approach will suffice. A qualitative analysis might be able to say that an impact of a trade agreement is likely to be “large” rather than “small,” but only a quantitative analysis can answer “how large?” or “how small?” questions. There are also many cases where economic theory cannot predict whether a variable increases or decreases. To take a simple example, a production quota carries both benefits and costs to producers: the market price increases on the units of a good that are sold but fewer units are sold because of the quota. Theory tells us the conditions under which one effect dominates the other but cannot say which conditions hold in a particular market.

Past performance in successfully predicting the effects of trade agreements can provide insights as to which modeling approach is the most appropriate, but there are two issues in this regard. First, many (or most) of the models used to measure the effects of trade agreements are policy models rather than projection models. That is, they are designed to estimate what the world would have looked like had a trade agreement been implemented in the model’s base period (e.g. 2005) rather than make projections about what the world will be like in the future with or without a trade agreement. Projections require assumptions about future changes in other relevant exogenous variables—depending on the model, these could be variables such as population, per capita income, crop/livestock yields, exchange rates, and policies other than the trade agreement. Second, even if we restrict ourselves to projection models, projections could be wrong not because of a failure to adequately represent the effects of a trade agreement but rather because of incorrect assumptions about future changes in exogenous variables or how changes in those exogenous variables will impact the economy.

KEY MODELING APPROACHES

The key approaches to measuring the effects of trade agreements can be grouped into two broad categories: econometric models and simulation models. In both approaches, a model consists of a system of mathematical equations that depict selected relationships in an economy or group of economies. Each equation has parameters that characterize how one economic variable is related to another within the model. With both approaches, a model can vary according to geographic scale (from a single farm field to the entire world), units of analysis (from individual firms to countries and global regions), temporal scale (daily to periods of several years), and product/sector scope (specific crop or livestock varieties to broad sectoral groupings such as agriculture as a whole).

Econometric and simulation models differ in how values are assigned to the parameters (McKitrick, 1998). In econometric models the parameters are estimated using statistical techniques. In simulation models parameter values are typically drawn from a variety of sources, including prior econometric studies, other simulation models, and analysts’ intuition and judgment. In essence, econometric models combine parameter estimation and model validation in the same analysis, while simulation models break these two steps apart. Parameter values in simulation models are usually assigned such that, given base-period policies and market conditions, the model exactly reproduces the model’s base period data. In both econometric and simulation models, economic theory is typically used to help assign parameter values (e.g. consumer demand equations must be homogenous of degree zero in prices and income).

In between these two broad categories are hybrid approaches that combine features of both econometric and simulation models. There are simulation models in which some parameters, such as Armington elasticities of substitution, are econometrically estimated while values of other parameters are obtained in the usual ways (e.g. Hertel et al., 2007). There are also econometric models in which some estimated parameters are adjusted based on analysts' intuition and judgment. For example, an analyst may believe that structural change in a market has caused a parameter to be larger or smaller than it was during the time period for which it was econometrically estimated.

Statistical estimation of parameter values has both benefits and drawbacks. It has the advantage that parameter estimates come with confidence intervals, so that the modeler can see their precision. Simulation modelers taking econometric estimates drawn from the literature typically ignore the precision of these estimates (Hertel et al., 2007; McKitrick, 1998). This can lead to false confidence in the reliability of model results if the results are highly sensitive to the values of parameters whose estimates are imprecise. Basing parameters values on a meta-analysis of prior econometric studies can alleviate this problem by showing the variability of estimates in the literature and providing a range of parameter values that can be tried (Abler, 2001). However, a meta-analysis is only possible if there a reasonably large number (say 20 or more) of estimates of a particular parameter in the literature. In many cases there are few or no existing estimates of a parameter.

Parameter estimation takes advantage of improvements in time series econometric techniques during the past two decades. Many of the parameters of popular simulation models can be traced back one way or another to time-series studies from the 1960s and 1970s. These parameters were estimated using econometric techniques that we now know are often fundamentally wrong and prone to serious estimation biases. Estimation also ensures that parameters are perfectly matched with the model, whereas using parameter estimates from prior studies can lead to modeling mismatches. Estimates from prior studies typically employ different levels of aggregation, and exploit different sources of price variation, than what policy modelers have in mind (Hertel et al., 2007). On the other hand, parameter estimation "locks in" a particular product/sectoring scheme, making it necessary to re-estimate parameters if products or sectors are redefined (Francois and Reinert, 1997).

Parameter estimation is intensive in research resources that could be used elsewhere (Francois and Reinert, 1997). One must balance the potential benefits of parameter estimation against any modeling or analyses that would be foregone. On occasion estimation can also produce econometric results that make no sense (e.g. a high income elasticity of demand for a basic grain like wheat in a developed country such as the US). Policy analysts who value their credibility would never use a nonsensical result such as this, but would probably move to a hybrid approach in which some parameters were adjusted to more intuitively plausible values.

Beyond the issue of parameter estimation, the chief advantage of econometric modeling is that it involves real data and, assuming a study is methodologically sound, provides real results. A well-done study indicates what actually happened in response to some trade agreement, and can provide a learning opportunity for the design and negotiation of future trade agreements. With a few exceptions (see Abrego and Whalley, 2005), simulation models of trade agreements are forward-looking "what if" exercises that do not seek to explain economic history.

A drawback of econometric modeling is that the results are specific to one country or one group of countries. For example, studies of CUSTA may be of some relevance to other bilateral trade agreements involving two developed countries, but their relevance to a trade agreement between a developed and developing country, or between two developing countries, is doubtful because of the much different nature of bilateral trade in those cases. Along the same lines, the results are specific to a trade agreement already in place, and they may not apply to a prospective trade agreement that has significantly different terms. This problem is exacerbated by the fact that most econometric studies utilize a pre/post methodology that assesses the effects of an entire trade agreement rather than breaking effects down by the individual components of the agreement. This leaves a policy analyst who is examining a particular component of a prospective agreement without econometric evidence on the impacts of similar components in previous agreements.

Another drawback of econometric modeling is that results are historical in nature and may no longer be relevant. By their nature, trade agreements often require significant changes in policies that fundamentally change the decisions faced by economic agents, and may lead to a new economic environment where historical relationships no longer hold. The well-known Lucas critique states that econometric models estimated under a specific set of government policies cannot be used to analyze a different set of policies because the parameters of an estimated model embody the policies under which the data were generated. As Just (2001), quoting an unnamed economic historian, puts it, “Economic history is all about structural change and econometrics is all about avoiding it” (p. 1136). Even when a trade agreement does not change the basic structure of agent decision making, it can cause economic variables to move far outside of the range of historical data. Econometric models are fundamentally backward-looking, and the domain of applicability of an econometric model is limited to the historical range of the data used to estimate the model (Devarajan and Robinson, 2005).

Table 1 summarizes the merits of econometric versus simulation models in terms of parameter values and model results on the criteria discussed here. Putting it all together, econometric models are the most suitable approach when the interest is on the historical impacts of a trade agreement already in place, impacts that may be helpful in the design and negotiation of future trade agreements. Econometric models are also the most suitable approach when the knowledge base upon which to draw parameter values for a simulation model is weak. Parameters capturing the impacts of trade on productivity and technological change are good examples. Simulation models are the most suitable approach when the interest is on a prospective trade agreement with significantly different terms from existing trade agreements, or trade agreements that cover different pairs or groups of countries than those in existing agreements. Simulation models are also the most suitable approach when the interest is on a prospective agreement that is likely to cause structural change in global or domestic markets, or one that is likely to lead to economic conditions outside of the range of historical data.

Table 1. Econometric versus Simulation Models

Criterion	Econometric Models	Simulation Models
Parameter Values		
Can determine precision of parameter estimates	✓	
Parameter values derived using modern econometric techniques	✓	
Parameter values perfectly matched with model	✓	
Avoids product/sectoring scheme “lock in”		✓
Economizes on research resources required to obtain parameter values		✓
Role for analyst judgment in avoiding nonsensical parameter values		✓
Model Results		
Real data, real results; no hypothetical exercises	✓	
Results can be generalized to different countries and regions		✓
Can analyze prospective trade agreement significantly different from existing agreements		✓
Can handle structural change that alters historical relationships		✓
Can handle economic conditions outside range of historical data		✓

ECONOMETRIC MODELS

Econometric models for measuring the effects of trade agreements fall into two general classes: models designed to predict trade flows between countries, and models designed to predict the economic impacts of trade. Economic impacts of interest in the literature include employment and wages, productivity, competition, and firm survival and exit.

Among models designed to predict trade flows between countries, by far the most popular modeling approach is the gravity model. The gravity model predicts that bilateral trade flows are proportional to the product of the incomes of two trading partners and inversely related to the distance between them. “Distance” in recent versions of the gravity model refers not only to physical distance but also to distance created by trade barriers; the presence or absence of colonial ties, customs unions, and common borders; the quality of political and economic institutions in the two trading partners (political stability, political and economic freedoms, control of corruption, enforceability of contracts, application of the rule of law); and distance created by differences in languages, ethnicities or religions (de Groot, Rietveld and Subramanian, 2004; Egger, 2002).

The gravity equation is one of the great success stories in economics, with many studies successfully accounting for variation in the volume of trade across country pairs and over time (Sheldon, 2006). Much of the recent literature on the gravity model has focused on strengthening its theoretical foundations, and on whether it can be used to distinguish among alternative theories of international trade (Anderson and van Wincoop, 2003; Evenett and Keller, 2002; Feenstra, Markusen and Rose, 2001). Recent empirical applications of the gravity model to trade agreements and their effects on agricultural trade include Nouve and Staatz (2003), who estimated the impacts of the Africa Growth and Opportunity Act on African exports to the US, and Skripnitchenko, Beladi and Koo (2004), who attempted to estimate the agricultural trade-creating and trade-diverting effects of several preferential trading arrangements (including NAFTA, the European Union, the Andean Community, and ASEAN).

There is a very large econometric literature on the economic consequences of international trade. Recent studies have looked at employment (Beaulieu, 2000; Levinsohn, 1999; Trefler, 2004), wages (Beaulieu, 2000; Trefler, 2004), productivity and technological change (Feenstra, 2004; Pavcnik, 2002; Krishna and Mitra, 1998; Trefler, 2004), competition (Krishna and Mitra, 1998), and firm survival and exit (Baggs, 2005; Pavcnik, 2002). CUSTA has drawn the attention of several researchers because of the relatively rich economic data available for Canada and the United States. These studies are not typically designed to test any particular economic theory. Instead they are designed to estimate relationships that may be important in analyzing the effects of trade agreements or in formulating theories of international trade, particularly longer-term effects on productivity and technological change. These effects are missing from most simulation models of trade impacts.

SIMULATION MODELS

Simulation models for measuring the effects of trade agreements fall into two general classes, partial equilibrium (PE) models and computable general equilibrium (CGE) models. CGE models are also referred to in some of the literature as applied general equilibrium (AGE) models. PE models cover a limited set of goods and services within an economy or group of economies. They consider the food and agricultural sector as a closed system that does not have significant effects on the rest of the economy, although the rest of the economy can still affect food and agriculture. CGE models cover all goods and services simultaneously within an economy or group of economies. They consider the food and agricultural sector as an open system that can potentially have significant effects on the rest of the economy. A large number of PE and CGE models have been used to analyze agricultural and trade policies. A good review of many of these models can be found in van Tongeren, van Meijl and Surry (2001). Other reviews in the context of the EU's Common Agricultural Policy (CAP) can be found in Conforti (2001) and De Muro and Salvatici (2001).

For reasons discussed above, it is pointless to argue whether PE or CGE is the superior modeling approach. Instead, the literature on PE and CGE modeling indicates that each approach has its benefits and drawbacks, making PE modeling the best choice in some circumstances and CGE modeling the best choice in others.

Economy-Wide Linkages

Capturing economy-wide linkages among producers and consumers is where CGE models shine. Changes in the agricultural sector could potentially have significant effects on national income and in turn demands for goods and services, including food. This is most likely to occur in developing countries where agriculture is a large percentage of national income. Changes in the agricultural sector could also have a significant impact on a country's real exchange rate, and in turn on prices of all goods and services. Once again this effect is most likely to be important in countries where agriculture is a large proportion of the economy. The agricultural sector could have significant impacts on wage rates, at least for some types of labor, in an economy where agriculture accounts for a large percentage of the labor force. By construction, PE models rule out linkages between agriculture and the rest of the economy. If there are reasons to believe that economy-wide linkages are likely to be important to the problem at hand, then CGE modeling is the preferred approach.

Conceptual Consistency

CGE models force conceptual consistency on a problem. They acknowledge a fixed resource base (land, labor, capital), measure the opportunity cost of factor movements between sectors as a result of a policy shock, and include explicit budget constraints for all households and for the government. PE models lack budget constraints that fully account for the opportunity cost of resources, and there is no linkage between factor income and expenditure (Conforti, 2001). Most PE models of the agricultural sector lack factor markets, instead expressing output supply (or acreage and yields for crops in some models) as a function of output prices only. An exception in this regard is the OECD's policy evaluation matrix (PEM) model, which has markets for land, farmer-owned inputs (labor and capital), and purchased inputs (Dewbre, Antón and Thompson, 2001).

Consistency with Theory

CGE models are designed from the ground up to be consistent with economic theory. The equations of a CGE model are derived from the assumption of optimizing behavior on the part of producers and consumers subject to budget and resource constraints. PE models, on the other hand, generally contain at least some inconsistencies with theory on both the supply and demand sides. For example, it is well-known that a system of consumer demand equations should be derivable from an underlying utility function, and as such should satisfy symmetry, homogeneity, and adding up requirements. Historically, most PE models ignored one or more of these requirements (Peterson, Hertel and Stout, 1994). Demand elasticities in PE models with constant-elasticity demand equations can be calibrated such that these requirements are satisfied in the model's base period, but in this case price movements away from base-period values will cause the requirements to be violated.

A CGE model's consistency with economic theory, combined with its conceptual consistency and ability to capture economy-wide linkages, makes it generally the best approach for social welfare calculations. A PE model can do a good job of estimating changes in producer surplus, consumer surplus, and net government expenditures within the agricultural sector but no more. A CGE model can provide theoretically consistent welfare calculations accounting not only for distortions within agriculture but also for how changes in the agricultural sector may diminish or augment distortions elsewhere in the economy (Gohin and Moschini, 2004).

Complexity

CGE models are highly intensive in data and parameters. Underlying each CGE model is a social accounting matrix (SAM) that records all transactions in an economy between firms, households, the government, and foreign entities. A SAM is constructed in an internally consistent manner such that supply equals demand for all goods and factors, tax payments equals tax receipts, there are no excess profits in production, household expenditures equal the value of factor income plus transfers payments, and government tax revenues equal transfer payments. The typical CGE model also requires that values be assigned to a large number of parameters, and for reasons discussed above this can be a difficult task. In many circumstances it may be difficult to justify devoting scarce resources to a complex CGE model when it may only yield marginal gains over basic insights drawn from a PE model (Francois and Hall, 1997).

Feasibility of Disaggregation

Generally, disaggregation of sectors into relatively fine categories is more feasible in a PE model than in a CGE model. Many countries have highly detailed trade policies applying to specific products that are a small proportion of the entire economy. Within a CGE model, each additional sector requires an additional row and column in the SAM showing that sector's receipts from, and payments to, all other sectors in the economy. For finely detailed sectors (e.g. different types of wheat), the necessary data to construct the SAM are unlikely to be available, making a PE model the only realistic approach (Francois and Reinert, 1997).

Finely detailed PE models excel at answering questions about "Ps and Qs"—changes in prices and quantities supplied/demanded for specific products that a CGE model could never answer. However, unlike a CGE model, a finely detailed PE model carries the risk of missing the forest for the trees. For example, a positive welfare effect in a detailed agricultural sector from a PE model is not necessarily more credible than a negative welfare effect for a more broadly-defined agricultural sector in a CGE model (that encompasses the detailed sectors from the PE model) simply because it is derived from an approach that yields finely detailed results. Detail is not a substitute for correct results.

Policy Representation

When incorporating a government policy into a simulation model, three properties are important: accuracy (the policy is represented in the model in a manner reasonably akin to how it actually operates); tractability (no unwieldy equations making it hard for the model to solve); and consistency with economic theory. Unless the policy is fairly simple, these three goals will come into conflict. In some cases the conflicts are minimal; in other cases they are substantial and choices among goals must be made.

CGE models by their nature require consistency with theory. PE models, on the other hand, can sacrifice some theoretical purity when needed to preserve the properties of accuracy and tractability, especially accuracy. The structure of PE models is more flexible than CGE models, making it easier to incorporate the complicated agricultural policy mechanisms that we observe in practice (Rude and Meilke, 2004). CGE models often represent agricultural and trade policies in a very simple manner through the use of “price wedges” that create a gap between domestic and world prices, or a gap between producer and consumer prices. Price wedges are consistent with theory and very tractable, but they may be a woefully inaccurate representation of how a policy actually operates (Anania, 2001).

Timeliness

CGE models often lag on policy and market information (Westhoff et al., 2004). For example, the most recent GTAP database (version 6) is for 2001 but was released in 2005. For many issues using a four- or five-year old database is perfectly acceptable. However, such a time lag is too long for many of the issues that PE modelers are called upon to address, such as short- and medium-term market projections, where timely data are crucial for accuracy and credibility with clients.

In addition, the GTAP database is revised only periodically—version 5 was for 1997 and version 4 for 1995. Moving from version 4 or 5 to version 6 has led the GTAP model and other CGE models that rely on the GTAP database to produce more modest estimates of global welfare gains from complete trade liberalization (Ackerman, 2005). This could be due in part to recent reductions in trade barriers that have lowered the base from which any trade liberalization exercise would start.

Length of Run

Most CGE models make assumptions that are long-run in nature, such as perfect factor mobility (capital, labor, materials) among sectors, and relatively high substitutability among inputs into production. As a result, the elasticities of output supply implied by most CGE models tend to be substantially greater than the supply elasticities used in most PE models. PE models typically take a short- to medium-run perspective in assigning values to supply elasticities and other parameters. This difference lies behind the greater responses in quantities, and smaller responses in prices, typically found in trade liberalization exercises using CGE models than PE models. Thus, the length of run of interest to the policy analyst can play a role in the choice of modeling approach.

Past Performance

Simulation modelers generally do not look back to see how accurate their projections of the impacts of trade agreements were, at least not in published papers. However, available publications suggest that both CGE and PE models have room for improvement on this criterion. Kehoe (2005) uses data on actual changes in trade flows among Canada, the US and Mexico between 1988 and 1999 to evaluate the performance of three prominent CGE models that were used in the early 1990s to estimate the impacts of NAFTA. He finds that these models dramatically underestimated the impact of NAFTA on North American trade. Trade relative to GDP increased by over 1,000% in many sectors between 1988 and 1999, while the CGE models predicted changes in trade relative to GDP of less than 50% in most sectors.

Kehoe (2005) argues that the Armington approach to substitution in consumption between domestic and imported goods in these CGE models had the effect of locking in pre-existing trade patterns and prevented the models from generating large changes in trade in sectors where little or no trade occurred before NAFTA. In fact, all models using an Armington assumption have a "stuck on zero trade" problem. If a country's imports of a product from another country are zero initially they will always be zero, regardless of changes in policy or market conditions. If imports are non-zero but small they will remain small even if there are large changes in prices. The Armington assumption is common to CGE models and many PE models, but it is not an inherent feature of either modeling approach. It may also be noted that very large numbers tend to be viewed with suspicion, and any model in the early 1990s projecting increases in trade of over 1,000% in response to NAFTA probably would not have been seen as credible.

Carpentier (2001) evaluated the performance of two *ex ante* PE models used to project the effects of NAFTA on North American agricultural trade against *ex post* assessments of the impacts of NAFTA. The *ex post* assessments attempted to isolate the effects of NAFTA from other variables influencing agricultural trade. In general, the *ex ante* models reviewed by Carpentier (2001) came closer to hitting the mark than the CGE models reviewed by Kehoe (2005). However, the PE models still tended to under-predict increases in agricultural trade, particularly in US exports of grains and oilseeds to Mexico. Carpentier (2001) does not discuss what features of these PE models might have led them to underestimate trade increases.

Table 2 summarizes the merits of CGE versus PE models in terms of the criteria discussed here. CGE modeling is the most appropriate for countries in which agriculture is a large proportion of the economy or countries in which agriculture accounts for a large percentage of the labor force. CGE modeling is also the most appropriate if the analyst is interested in social welfare calculations. On the other hand, PE modeling is the most appropriate if the focus is on finely detailed sectors (e.g. different types of wheat) or on complicated agricultural policy mechanisms that are difficult to represent accurately and tractably without sacrificing some consistency with economic theory. Because CGE models typically lag on policy and market information, PE modeling is also the most appropriate for issues where timeliness is crucial. CGE models tend to generate results that are long-run in nature, while most PE models are constructed with a short- to medium-run perspective.

Table 2. Computable General Equilibrium (CGE) versus Partial Equilibrium (PE) Models

Criterion	CGE Models	PE Models
Capturing economy-wide linkages among producers and consumers	✓	
Conceptual consistency that recognizes resource and budget constraints	✓	
Consistency with economic theory	✓	
Avoiding complexity in data and parameters		✓
Ability to disaggregate sectors into relatively fine categories		✓
Ability to represent complicated policy mechanisms observed in practice		✓
Use of timely data		✓
Capturing short- and medium-run effects		✓
Capturing long-run effects	✓	
Past performance in projecting impacts of trade agreements	(neither has an edge)	

Conclusions

Clarity and credibility in applied trade policy analysis suggest that a single modeling approach should be chosen that is most appropriate for the problem at hand. In choosing a modeling approach the desire for broad sectoral, product, policy, and country coverage must be balanced against the need for detailed and accurate coverage of particular markets and policies.

The key approaches to measuring the effects of trade agreements can be grouped into two broad categories: econometric models and simulation models. The two categories differ in regard to how values are assigned to model parameters—in econometric models the parameters are estimated statistically while in simulation models they are typically drawn from prior econometric studies, other simulation models, and analysts' intuition and judgment. Within the econometric approach, there are models designed to predict trade flows between countries (most of which are applications of the gravity model), and models designed to predict the economic impacts of trade. Within the simulation approach, there are partial equilibrium (PE) models and computable general equilibrium (CGE) models.

Econometric models are the most suitable approach when the interest is on the historical impacts of a trade agreement already in place, impacts that may be helpful in the design and negotiation of future trade agreements. Econometric models are also the most suitable approach when the knowledge base upon which to draw parameter values for a simulation model is weak. Parameters capturing the impacts of trade on productivity and technological change are good examples. Simulation models are the most suitable approach when the interest is on a prospective trade agreement with significantly different terms from existing trade agreements, or trade agreements that cover different pairs or groups of countries than those in existing agreements. Simulation models are also the most suitable approach when the interest is on a prospective agreement that is likely to cause structural change in global or domestic markets, or one that is likely to lead to economic conditions outside of the range of historical data.

Between PE and CGE modeling, CGE modeling is the most appropriate for countries in which agriculture is a large proportion of the economy or countries in which agriculture accounts for a large percentage of the labor force. CGE modeling is also the most appropriate if the analyst is interested in social welfare calculations. On the other hand, PE modeling is the most appropriate if the focus is on finely detailed sectors (e.g. different types of wheat) or on complicated agricultural policy mechanisms that are difficult to represent accurately and tractably without sacrificing some consistency with economic theory. Because CGE models typically lag on policy and market information, PE modeling is also the most appropriate for issues where timeliness is crucial. CGE models tend to generate results that are long-run in nature, while most PE models are constructed with a short- to medium-run perspective.

When measuring the effects of trade agreements the problem for economists is usually not a lack of answers but rather an abundance of them. The guidelines in this paper are intended to hopefully reduce the cacophony and produce more a consistent and convincing story on the effects of trade agreements on the food and agricultural sector.

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IMPLICATIONS OF DOMESTIC SUPPORT DISCIPLINES FOR FURTHER AGRICULTURAL TRADE LIBERALIZATION

Keith Walsh[a,*], Martina Brockmeier [b] and Alan Matthews [c]

[a] Business School, Dublin City University and Institute for International Integration Studies, Trinity College, Dublin, Ireland.

[b] Federal Agricultural Research Centre (FAL), Braunschweig, Germany.

[c] Department of Economics and Institute for International Integration Studies, Trinity College, Dublin, Ireland.

ABSTRACT

This article employs the GTAP model and dataset to analyze the implications of domestic support reductions in the context of agricultural trade liberalization. Three specific issues are addressed: overhang in domestic support, the accurate distinction of the boxes in the GTAP dataset and the treatment of market price support in the amber box. An extensive domestic support database is used to calculate the change in applied domestic support rates resulting from a specified cut in bound rates, and to identify the impact on the different domestic support boxes and the required reductions in each support category. The GTAP model is extended to incorporate the market price support element of the AMS. The results highlight the importance of accurate modeling of domestic support disciplines in estimating the impact of a potential Doha Round agreement on agriculture. They support the view that the impact of an agreement to reduce domestic support will be lower than conventionally estimated.

Keywords: WTO agricultural negotiations, domestic support, agricultural protection, Aggregate Measure of Support.

The Doha Round of World Trade Organization (WTO) trade negotiations launched in September 2001 was suspended in July 2006, in part because of the inability of member countries to reach agreement on the level of ambition for, and structure of, reductions in tariff barriers and trade-distorting domestic support in agriculture (for overviews of the negotiating issues in agriculture, see WTO 2004; IPC 2005). The difficulties in the agricultural

* Corresponding author: Keith Walsh, Business School, Dublin City University, Dublin 9, Ireland. Tel.: 00353-1-7005589. Email: keith.walsh@dcu.ie.

negotiations stem partly from the lack of political will to face down the domestic interest groups which benefit from agricultural protection, but also from more technical issues concerning the lack of transparency of the extent to which particular rule changes would lead to increased market access and trade. This uncertainty about negotiating outcomes is reflected in empirical studies which attempt to estimate the likely impact of a Doha Round agreement on agriculture. A wide range of estimates can be found in the literature, depending on the liberalization scenarios examined, the data used, behavioral parameters assumed and model specification (Bouet 2006). While model results will always be sensitive to the specific assumptions made, progress in modeling should help to narrow these differences and separate good modeling practice from bad.

Keeney and Hertel (2005) show the importance of correctly modeling agricultural policies if computable general equilibrium (CGE) estimates of the impacts of agricultural trade liberalization are to be considered accurate and realistic. For example, the importance of taking into account the distinction between bound and applied tariffs is now well recognized in empirical studies (e.g., Bouet *et al.* 2004). The aim of this article is to assess the implications of accurately modeling particular features of domestic support in the simulation of further agricultural trade liberalization in the context of the current Doha Round of multilateral trade negotiations when using the Global Trade Analysis Project (GTAP) model and database. The GTAP database is very widely used in empirical studies of trade policy reform. Three issues related to the modeling of domestic support in GTAP are addressed: the issue of overhang in domestic support; the distinction between the different domestic support boxes in GTAP; and the representation of the market price support component of domestic support in the model.

Redundant support entitlements – sometimes referred to as domestic support overhang – are one complication in negotiating reductions in domestic support. Domestic support is disciplined under the WTO Agreement on Agriculture by setting an upper limit on each country's Total Aggregate Measure of Support (AMS). For many WTO members, their current Total AMS is considerably lower than their bound commitment level. Thus simulating further domestic support reduction by cutting applied support by the headline reduction in bound support leads to unrealistic and disproportionate results.

Analysis of domestic support reductions is further complicated by the different categorization of support (boxes) in the WTO Agreement on Agriculture. Cuts in domestic support are often simulated as reductions of all direct payment measures in the GTAP model, whereas green or blue box payments were not cut in the Uruguay Round and *de minimis* amounts were exempted. The Doha Round agreement will see the blue box disciplined for the first time as well as new disciplines on overall trade-distorting support.

A further issue is the modeling of reductions in trade distorting support in the amber box. Protection measures included in this box include market price support and direct payments coupled to production. Market price support (MPS) is included in the amber box when it is underpinned by an applied administered price. Cutting MPS contributes to reducing AMS and, consequently, reduces the need to cut non-exempt direct payments as a way of meeting Total AMS disciplines. Most studies ignore the fact that the AMS can be lowered by reducing the administered price, in part because MPS measures are only implicitly represented via border protection in the standard GTAP model.

We run two sets of experiments, called single pillar and three pillar simulations. The single pillar simulations focus solely on reductions in domestic support. A series of experiments is run to demonstrate the impact of the three identified issues on the simulation results. The three pillar simulations include disciplines on all three pillars of the Agreement on Agriculture (market access, export competition and domestic support). This allows the interaction between tariff reductions and domestic support reductions to be explored. One of the lessons from these simulations is that there is considerable flexibility in the way countries can decide to meet stricter domestic support disciplines in an eventual Doha Round agreement. Any simulated liberalization is sensitive to the specific assumptions made regarding how countries will strike the balance between MPS and direct payment reductions, between reductions in the different components of overall trade-distorting support, as well as between support reductions across commodities.

The second section describes the representation of domestic support in the standard GTAP model and briefly reviews the current literature on modeling domestic support in the context of further agricultural trade liberalization.The third section outlines the construction of a domestic support dataset and the extension of the standard GTAP model to incorporate the improved treatment of domestic support. Simulations and results are discussed in the fourth section. The final section reflects on the implications of these results.

DOMESTIC SUPPORT AND TRADE LIBERALIZATION

The commitments of the Uruguay Round Agreement on Agriculture (URAA) fall into three categories, known as pillars: domestic support, market access and export competition. Within the domestic support pillar measures are assigned to different categories, referred to informally as “boxes”. The color of a box indicates the fate of the subsidies allocated to it.

Outcome of the Uruguay Round

Measures that distort trade and production fall into the amber box (as defined in Article 6 of the Agreement). These include MPS, direct payments coupled to production and other budgetary outlays on production distorting policies. The value of MPS is calculated as the difference between an applied administered price per ton and an external reference price per ton, multiplied by eligible tonnage. The monetary value of such support, excluding permitted exemptions described below, is referred to as the Aggregate Measure of Support (AMS). The Total AMS is the maximum level of such support which may be provided by a country under the Agreement. The current Total AMS (or current AMS) is the actual amount of such support provided and reported by each member in its annual notifications to the WTO.

Certain support measures are exempted from the amber box. Support that has little or no impact on trade and production and meets specific criteria defined in Annex 2 of the Agreement qualifies for the green box. In addition, some distorting payments are exempt from the amber box and are not counted in a country’s current AMS. First, some programs in developing countries are exempted if they conform to the criteria in Article 6.2 (sometimes referred to as the development box). Second, distorting payments may be excluded and placed in a separate blue box category if they are conditioned on limiting production (the criteria are defined in Article 6.5 of the Agreement). Third, domestic support that is less than a *de* *minimis* threshold of 5 per cent of the value of production (10 per cent for developing countries) is excluded from a country's calculation of its current AMS. The *de minimis* threshold applies to product specific and non-product specific supports.

Under the URAA, members committed to bind and reduce their Total AMS in percentage terms over a period of six years from 1995 (ten years for developing countries). Industrialized countries agreed to cuts of 20 per cent, with special and differential treatment applied to developing countries (13.3 per cent) and least-developed regions (no cuts). As noted in the introduction, it is often the case that a domestic support overhang exists, whereby a country's current AMS is lower than its permitted bound Total AMS. Countries without Total AMS commitments are only allowed *de minimis* levels in future. Under the URAA, no limits were placed on the value of the blue and green boxes other than the need to meet the eligibility requirements laid out in the Agreement.

Domestic Support in the Standard GTAP Model and Database

The GTAP model is a static, one period, CGE of the world economy. All markets in the model are perfectly competitive and exhibit constant returns to scale. The base year of the most recent version of the GTAP database (Version 6) is 2001. Hertel (1997) and Dimaranan and McDougall (2006) provide detailed descriptions of the model and database respectively.

In the standard model, agricultural support is represented in two ways. First, MPS is modeled implicitly via border protection rates with tariff data taken from the MAcMap dataset.[1] The applied administered prices are not represented directly. Second, non-market price support is represented by various kinds of subsidy wedge. The source of the agricultural support data for non-market price support protection in industrialized countries is the Producer Support Estimates (PSE) produced by the Organization for Economic Cooperation and Development (OECD 2002a). To incorporate the direct payments reported in the PSE data into the GTAP model, they are allocated to four different categories of support for each commodity: output subsidies, intermediate input subsidies, land-based payments and capital-based payments. These PSE categories include direct payments corresponding to both the blue and green boxes of the WTO classification of agricultural subsidies as well as *de minimis* payments.

Review of Literature on Modeling Liberalization and Domestic Support

There is now a voluminous literature assessing the implications of agricultural trade liberalization. We review in this section studies that have made a particular effort to model domestic support disciplines.

Hart and Beghin (2005) examine the impact of redefining AMS and the blue and green boxes. Noting the importance of MPS in total AMS in the US and the EU, they demonstrate the impact of using different applied and external reference prices in the calculation of AMS. They also highlight the option for WTO members to reduce their notified levels of domestic

[1] See www.macmap.org for more information on MAcMap.

support via cuts in applied administered prices, without actual reductions in support provided to producers.

Brink (2006) examines the October 2005 proposals of the US, EU and the G20 on domestic support in the Doha Round negotiations. Based on projections of agricultural production to 2014, Brink calculates future levels of domestic support commitments and concludes that there is substantial potential for the EU, the US and other producers to reduce their commitment levels (i.e., their bound ceilings) in all three proposals, without implementing any major reform of agricultural policies. Similar conclusions are drawn by de Gorter and Cook (2005) based on the 2004 Framework Agreement. Calculations by Jensen and Zobbe (2005), which take into account reforms of agricultural policy such as the Mid-term Review in the EU and the 2002 US Farm Bill, confirm the findings of Brink, but they also show that many other countries, even those with relatively low domestic support ceilings, have high levels of overhang in their AMS.

Many CGE studies have implemented agricultural liberalization scenarios by cutting overall domestic support with no attempt to distinguish between allowed and disciplined subsidies, nor between the direct payment and MPS elements of the AMS (e.g., Dimaranan *et al.* 2003; Francois *et al.* 2005; Hertel and Keeney 2005 and Polanski 2006). To better address the distinction of the boxes, Rae and Strutt (2003) consider land- and capital-based payments to be proxies for the blue and green boxes and output and intermediate subsidies as approximating amber box payments. However, this overestimates the size of amber box support in the GTAP database. Some recent studies have constructed extensive domestic support databases. Papers that have followed this approach include Bouet *et al.* (2004), Anderson *et al.* (2005) and Jensen and Yu (2005). This allows for only trade distorting domestic support to be reduced and to take into account the degree of overhang. However, none explicitly model the fact that the AMS measure covers MPS as well as direct payments. Using a CGE model and data from GTAP, Burfisher *et al*. (2002) distinguish between the boxes and model price support. However, like some of the above studies (e.g., Hertel and Keeney 2005) they implement a full liberalization scenario and thus the degree of overhang is not relevant to their simulation design.

The scenarios in our study are constructed to show the likely magnitude of the bias associated with modeling strategies which do not take these features into account. For this purpose, we explicitly allocate support data in the GTAP database into amber, green and blue box supports. This classification has also been made in previous papers but the underlying data are not easily accessible. We also propose a method to take into account the dual nature of the AMS measure as well as modeling *de minimis* thresholds for each commodity.

METHODOLOGY

The GTAP aggregation used in this article is shown in table 1. The regional aggregation focuses on five countries: EU, US, Canada, Japan and Brazil. These countries account for over 85 per cent of permitted Total AMS in 2001. At the sector level, all twelve primary agricultural commodities in GTAP are kept separate, as well as the six food-processing sectors such as beef and sheepmeat and dairy.

Table 1. Regional and Sectoral Aggregation

Regions	Sectors	
European Union	Rice	Raw Milk
United States of America	Wheat	Silkworm Cocoons, Wool
Canada	Other Cereals	Beef and Sheepmeat
Japan	Vegetables and Fruits	Other Meat Products
Brazil	Oilseeds	Vegetable Oils and Fats
Australia & New Zealand	Sugar Cane and Beet	Dairy Products
Rest of Mercosur	Plant-based Fibers	Processed Rice
Everything But Arms Countries [a]	Other Crops	Sugar
China	Cattle, Sheep and Goats	Manufacturing
Rest of the World	Pigs and Poultry	Services

Note a: This region includes those countries distinguished in the GTAP database which benefit from duty-free access to the EU market under its 'Everything But Arms' preferential scheme.

The standard GTAP model and database are extended in two ways to address the issues raised in this article. A detailed domestic support dataset is used to allocate domestic support data in GTAP into amber, blue and green boxes, as well as identify the degree of overhang for each commodity and region analyzed in this article. The treatment of the MPS element of AMS is addressed by the extension of the GTAP model.

Construction of the Domestic Support Dataset

The assembly of this dataset is summarized here and described fully in appendix 1. The annual domestic support notifications of member countries to the WTO are used as the primary source. The dataset is constructed for 2001 to enable a comparison with the current GTAP database.

Domestic support for each of the five countries considered as shown in their notifications is categorized by box and by commodity. It is then linked to the domestic support shown in GTAP for each of the twelve primary agricultural commodities. Table 2 provides a summary of the resulting domestic support figures for each region and the allocation of GTAP support to the various boxes. It should be noted that these figures are calculated before the implementation of a baseline pre-experiment simulation which is outlined below.

In table 2, the levels of current Total AMS and final bound Total AMS are shown and the degree of overhang is calculated. The current levels of blue and green box support in each region are shown. As it was agreed in the July 2004 Framework (WTO 2004) that blue box support would be capped at 5 per cent of the value of production in the future, current support as a value of production is also indicated.

Overall distorting support (ODS) is the sum of trade distorting support. Base ODS is defined (in the July 2004 Framework Agreement) as the sum of final bound Total AMS, permitted *de minimis* (both product and non-product specific) and the agreed level of blue box support (defined as the higher of existing blue box support or the 5 per cent cap). We define current ODS is the sum of current Total AMS, current *de minimis* and current blue box support. Comparison of current and base ODS provides a measure of ODS overhang.

Table 2. Levels of Domestic Support in 2001
(Pre-Baseline Experiment - Millions of US dollars)

		EU	USA	Canada	Japan	Brazil
Bound Total AMS		65,383	19,103	2,777	32,691	954
Market Price Support		25,492	5,826	295	3,242	0
Direct Payments		10,905	8,802	349	2,379	236
Non-Product Specific Support		1,372	6,828	1,346	165	740
AMS (product and non-product specific)		37,769	21,456	1,990	5,785	976
De Minimis		2,000	7,043	1,513	264	976
Current Total AMS		35,769	14,413	477	6,049	0
Blue Box ($ Millions)		21,261	0	0	749	0
Blue Box (% of value of production)		9%	0%	0%	1%	0%
Green Box		19,452	50,672	1,108	21,023	1,794
Of which: Development Box		-	-	-	-	332
Base Overall Distorting Support [a]		110,502	48,879	6,022	76,537	6,715
Current Overall Distorting Support [b]		59,030	21,456	1,990	7,062	976
Overall Distorting Support Overhang [c]		47%	56%	67%	91%	85%
Domestic Support in GTAP						
Total		44,103	32,548	2,486	4,580	496
Output Subsidies		3,800	9,537	263	1,465	496
Intermediate Subsidies		5,349	6,995	270	972	0
Land-based Payments		20,955	15,588	1,863	974	0
Capital-based Payments		13,999	428	90	1,169	0
Classification of GTAP Support to Boxes						
Amber Box	Output Subsidies	3,653	8,859	249	414	481
	Intermediate Subsidies	4,958	6,567	205	867	0
	Land-based Subsidies	103	486	403	907	0
	Capital-based Subsidies	905	392	84	989	0
Blue Box	Output Subsidies	0	0	0	750	0
	Intermediate Subsidies	56	0	0	0	0
	Land-based Subsidies	16,715	0	0	0	0
	Capital-based Subsidies	7,144	0	0	0	0
Green Box	Output Subsidies	147	678	14	301	15
	Intermediate Subsidies	335	428	65	105	0
	Land-based Subsidies	4,137	15,102	1,460	67	0
	Capital-based Subsidies	5,950	36	6	180	0

Source: Notifications to the WTO (Various) and own calculations (see appendix 1 for details).

Note a: Base ODS is the sum of bound Total AMS, permitted *de minimis* (both product specific and non-product specific) and agreed level of blue box support.

Note b: Current ODS is the sum of current Total AMS, current *de minimis* (both product specific and non-product specific) and current blue box support.

Note c: Overhang is the difference between current and bound/base levels, expressed as a percentage of the bound/base total.

Incorporation of Market Price Support in the GTAP Model

The standard GTAP model is extended to incorporate an explicit representation of the MPS component of the AMS. MPS mechanisms and the extension of the model are described in detail in appendix 2. In brief, MPS is introduced to the model via a complementarity function that ensures, if the market price of a commodity falls sufficiently, this will result in a cut in the commodity's applied administered price for the purposes of the AMS calculation, thus endogenously reducing the level of AMS. Such reduction in the MPS component of the AMS would then allow a country to make smaller reductions in its trade-distorting direct payments. Because the size of these latter reductions is set exogenously outside the model, it is not possible to incorporate this interdependency endogenously into the model extension. If an endogenous reduction in the MPS component occurs, then the required reduction in the non-MPS elements must be recalculated and the simulation rerun. It may be necessary to repeat this exercise a number of times until an acceptable level of convergence with the target cut in AMS is achieved.

The calculation of the value of MPS, summed together with the appropriate, non-exempt direct payments, enables the calculation of AMS in the model. Combined with data from the domestic support dataset described in the previous section, the amber, blue and green boxes can now be accurately represented at the GTAP aggregation level.

Baseline Pre-Experiment Simulation

A detailed pre-simulation experiment is implemented to construct a baseline against which to compare the results of the simulations in the article. The baseline introduces changes to the policy landscape that have already taken place since 2001 (the base year of the GTAP database) or that are expected to occur during the following years. The policy changes included in the baseline are: the accession of the People's Republic of China to the WTO in 2001; the completion of the Agenda 2000 Reform of the EU's Common Agricultural Policy (CAP); the eastern enlargement of the European Union; the 2003 Mid-term Review of the CAP which largely decoupled the EU's direct payments from current production; the complete implementation of the EU's Everything But Arms (EBA) agreement and the elimination of MFA textile quotas. Following the approach of Jensen and Frandsen (2003) and others, decoupled direct payments in the EU are modeled as uniform payments to agricultural land across all sectors. The justification for this approach is that land must be kept in good agricultural condition to receive the payment and that land has no other use outside of agriculture in GTAP.

SIMULATIONS AND RESULTS

Two sets of simulations are implemented. The first set of simulations focuses on the domestic support pillar of the URAA only (referred to as Single-Pillar Simulations). These simulations focus on methodology, they identify and illustrate the three issues in modeling domestic support addressed in this article. The second set of simulations is composed of two experiments that model the interaction between domestic support reductions and liberalization of the other two pillars, i.e., market access and export competition (referred to hereafter as Three-Pillar Simulations).

Single-Pillar Simulations

There are four single-pillar simulations. Beginning with a simple domestic support reduction based on the standard GTAP dataset, successive simulations build on this to illustrate the importance of domestic support overhang, the accurate distinction of the boxes, and modeling both the direct payment and MPS components of the amber box.

These experiments are not intended to represent any particular policy scenario. Cuts are implemented based on tiered reductions in ODS. Member countries are assigned to tiers based on their absolute levels of protection, as measured by their levels of ODS. The EU is placed in the top tier, the USA and Japan in tier two and Brazil and Canada in the lowest tier. The tiers are assumed to implement headline cuts in base ODS of 90, 80 and 70 per cent respectively (Brink 2005). The sensitivity of products is not considered, so all reductions are linear across commodities within each region. For the other five regions disaggregated in this article no domestic support reductions are implemented.

The first simulation is implemented with the standard GTAP dataset. All domestic support measures in the GTAP database, i.e., the direct payments modeled as output subsidies, intermediate input subsidies and land- and capital-based subsidies, are reduced by the headline cuts in base ODS assumed for countries in each tier. Simulation 2 also employs the standard version of the dataset, but in this case the degree of domestic support overhang is taken into account. The reductions in current ODS required to meet the cuts in base ODS are calculated. As indicated in table 2, the levels of current and base ODS vary widely between countries. A comparison of the results with simulation 1 illustrates the relative importance of overhang in modeling domestic support.

In the first two simulations, all measures of domestic support in the GTAP database are reduced, albeit by different amounts. In simulation 3, we distinguish the different boxes in the database based on the classification of subsidies in the domestic support dataset. For all regions, green box measures notified to the WTO account for at least one third of total notified domestic support. Only Japan and the EU make use of the blue box in 2001.[2] The same cuts in current ODS as in simulation 2 are implemented (taking into account the degree of overhang), but only amber box (measured by Total AMS) and blue box direct payments are cut. Total AMS and blue box support are reduced equally, by the percentage required to achieve the reduction in base ODS. The MPS component of Total AMS is not cut and green box supports are excluded from reduction.

Simulation 4 employs the extended GTAP model described above. This allows MPS changes to be modeled. In this simulation, domestic support is reduced as in simulation 3, taking into account the degree of overhang and only targeting the amber and blue boxes. However, we now allow governments to achieve their target cuts in current Total AMS by also reducing MPS. Crucially, we assume that a reduction in MPS brought about by lowering the applied administrative price has no impact on the effective protection provided to producers, which is determined by the level of border protection. For purposes of illustration, we assume equal percentage reductions in the MPS and non-exempt direct payment components of the Total AMS. The relative importance of each component to the Total AMS

[2] The simulation is based on post-baseline data. It incorporates the transfer of decoupled direct payments in the EU from the blue to the green box and increases the degree of overhang for the region.

cut will depend on their shares of total amber box support in each region. The distribution of amber box support between MPS and direct payments in each region is shown in table 2.

The results of the first set of single-pillar simulations examine the impact of domestic support reductions alone. As the focus of these simulations is on the techniques used in modeling domestic support, we do not dwell on the interpretation of the figures; rather we focus on comparisons of the change in welfare across the four simulations that allow an analysis of the three issues (table 3). For this purpose, the results of simulation 1 provide a benchmark against which to compare the other experiments.

In simulation 1, the world economy obtains welfare gains of almost \$6 billion overall. This is driven by gains in the EU and US as these regions reduce their levels of distorting support. Most of this increase comes from improved allocative efficiency, allowing for a more efficient allocation of resources within countries. The EU enjoys the greatest allocative efficiency gain, as a result of being the region with the highest level of support and being placed in the top tier of domestic support cuts. There is also a terms of trade effect from the liberalization scenario, with mixed impacts across regions. These effects reflect the net trade position of the various regions, particularly for those commodities in receipt of domestic support.

In simulation 2, less domestic support is eliminated compared to the first simulation, and the total gain to global welfare is reduced to \$5 billion. This result holds across all regions except Japan (whose welfare loss increases) and the EBA group of countries (almost no change). If the headline reductions in base ODS were any lower (and we have chosen figures at the high end of the likely range), the disparity between this result and simulation 1 would be even greater.

In the third simulation, only coupled direct payments and the blue box are reduced, by the required rates to meet the reductions in base ODS (taking the degree of overhang into account). Because a substantial share of the blue box in the EU has been decoupled and transferred to the green box in the baseline experiment, this further reduces the amount of support cut in this simulation. The overall welfare change is valued at \$3.2 billion, lower than in the first two simulations, and the magnitude of the results for each individual region is also lower compared to simulation 2. The decomposition of the welfare changes for the EU, the US and Japan remains the same as simulation 2.

Simulation 4 employs the extended model to reduce current Total AMS and the blue box by the same amounts as in the previous simulation, but reduced MPS now contributes half of the required target AMS cut. The total welfare change for the world economy is further reduced to \$2 billion. Countries can reduce applied administered prices without changing the level of effective protection provided to producers. The distribution of AMS between MPS and direct payments also influences the result for each country.

A comparison across the four single-pillar simulations illustrates the impact on the simulation results of taking into account the issues of domestic support overhang, the distinction between the boxes and a more complete representation of the amber box instruments. The welfare gains are reduced overall by almost two thirds, with the effects for individual regions determined by the interaction of allocative efficiency and terms of trade effects.

Table 3. Welfare Change in Simulations 1-4
(Millions of US dollars)

Region	Simulation 1				Simulation 2				Simulation 3				Simulation 4			
	Total	AE	TOT	IS	Total	AE	TOT	IS	Total	AE	TOT	IS	Total	AE	TOT	IS
EU	4,608	5,584	-1,031	55	4,522	5,244	-759	37	2,832	2,973	-143	2	1,696	1,770	-80	6
USA	2,369	1,231	1,513	-375	1,882	1,056	1,028	-201	645	409	239	-3	418	306	126	-14
Canada	451	46	400	6	268	-4	271	1	91	8	87	-3	52	7	47	-1
Japan	-323	78	-480	79	-475	-324	-179	28	-89	-74	-13	-1	-48	-48	-1	1
Brazil	484	54	403	27	278	12	252	13	45	5	38	2	30	3	25	2
Australia/New Zealand	382	-1	385	-2	260	-2	263	-2	55	0	56	-1	31	0	31	0
Rest of Mercosur	319	34	293	-7	217	23	199	-5	47	4	45	-1	30	3	28	-1
EBA Countries	-129	-43	-77	-9	-125	-31	-86	-8	-67	-9	-54	-4	-43	-6	-35	-2
China	-404	-182	-312	89	-250	-110	-192	52	-37	-10	-29	2	-19	-6	-17	3
Rest of the World	-1,775	-816	-1,096	137	-1,301	-587	-798	85	-318	-101	-224	7	-167	-50	-125	7
World Total	5,983	5,986	-2	0	5,276	5,277	-1	0	3,205	3,205	0	0	1,979	1,980	0	0

Source: GTAP model simulation results.

Notes: Welfare is measured as equivalent variation in millions of US dollars.

Total = Total welfare change (sum of the AE, TOT and IS effects).

AE = Allocative efficiency effect

TOT = Terms of trade effect

IS = Investment-Savings effect.

Three-Pillar Simulations

The second set of simulations combines domestic support reductions with improvements in market access and disciplines on export competition. The modeling of the reductions in domestic support is also more detailed than in the single-pillar simulations. The July 2004 Framework Agreement provides the structure used to model the domestic support disciplines, although many assumptions must be made in order to generate a series of implementable shocks.

The reduction of base ODS and placement in tiers is assumed to be same as in the single-pillar simulations. In addition, bound Total AMS is also reduced based on a tiered formula. The placement of countries in tiers for cuts in Total AMS in this article is assumed to be same as for ODS. The reductions assumed are 80, 70 and 60 per cent respectively for the three tiers. Blue box supports are reduced and capped at 5 per cent of total agricultural production in 2001. A linear 60 per cent cut is imposed on *de minimis* support, the final component of ODS. The threshold is reduced to 2 per cent for industrialized countries, and to 6 per cent for developing countries.

Given the reductions assumed in the headline cuts in base ODS and bound Total AMS above, members must then decide how to implement these cuts. For the reduction in Total AMS, an initial comparison between the bound commitment and the current level identifies the degree of overhang and actual cut necessary to achieve the target reduction (table 2). The degree of overhang is sufficient for Japan, Canada and Brazil to implement the cuts to their bound Total AMS levels without reducing current Total AMS.

Once the level of reduction required in current Total AMS is calculated, countries face a choice in distributing the cuts across commodities. Reductions may be linear across all commodities or certain sensitive commodities may face less than proportionate cuts. We consider a scenario based on the latter option. Relative levels of current domestic support compared to total output value are used as a proxy for the sensitivity of each commodity. Products are placed in tiers depending on their sensitivity and deeper cuts are implemented for those commodities deemed less sensitive. Product specific supports are capped at their 2001 levels to prevent shifting of support between commodities.

Countries also face a choice how to implement these reductions. Current Total AMS can be cut by reducing non-exempt direct payments or by cutting MPS, or both. Under the assumptions made here, the USA and the EU must reduce current Total AMS by 60 and 62 per cent respectively, but their distribution between MPS and direct payments is markedly different.

Countries are assumed to implement current Total AMS cuts by reducing coupled direct payments initially. For some commodities, depending on the distribution of amber box support between coupled direct payments and MPS, even reducing direct payments to zero is not sufficient to achieve the target cut. In such cases, it is assumed that the remainder of the cut is achieved by reducing the MPS component of the amber box. We chose this assumption on the basis that it maximizes the likely impact of domestic support reduction commitments, but it is only one of a number of strategies that affected countries might pursue.

The other components of ODS are also considered. As table 2 shows, for all countries except the EU, blue payments were already less than the 5 per cent cap in 2001. For the EU, assuming its decoupled support is classified in the green box, blue box payments will also fall below the new 5 per cent cap. This effectively becomes another source of overhang and therefore assists the EU in achieving its overall target commitment.

The effectiveness of a reduction in *de minimis* support is felt differently across regions. The reduction is particularly large in the US, owing to the fact that non-product specific support now exceeds the new threshold level. The interaction of reducing *de minimis* with the levels of current Total AMS is also modeled. For those countries with bound Total AMS commitments, any reduction in the threshold level results in an equivalent increase in current Total AMS because support payments which previously fell below the *de minimis* level now exceed the new threshold.

The sum of the reductions of the individual components of ODS are then compared to the overall reduction target in base ODS. If the overall target is not achieved, members must implement deeper cuts to some element or elements of ODS. Whether they choose to reduce current Total AMS or blue box or *de minimis* further is at their discretion.

In the simulation described above, the only country of the five modeled here to achieve the final base ODS target reduction is Japan. Further cuts are required for the US, the EU, Canada and Brazil. These countries are assumed to further reduce their current Total AMS, with the cuts applied equally to MPS and direct payments.

These assumptions can be altered, but they illustrate the extent to which any ex-ante assessment must make assumptions about how a cut in base ODS and its components are implemented even when the headline reductions are known. The calculations are made outside of the model using the domestic dataset described above and in appendix 1.

Simulations 5 and 6 implement reductions in domestic support combined with disciplines on market access and export competition for agricultural goods. In both simulations, these are modeled as a linear 50 per cent reduction of global agricultural import tariffs and the elimination of export subsidies on agricultural goods by all countries. This is an illustrative cut in applied tariff rates and the degree of tariff overhang is not considered, nor is any special and differential treatment for developing countries implemented. The only difference between the two simulations is the treatment of domestic support.

In simulation 5, the standard database is employed and domestic support is reduced by the base ODS rates (90, 80 or 70 per cent cuts for the three tiers).[1] Domestic support cuts are the same as the first single-pillar simulation, with all direct payments in the database being reduced and linear cuts implemented across commodities. The degree of domestic support overhang, the distinction between the boxes and the MPS component of the AMS are not considered.

Simulation 6 employs the extended GTAP model and database to implement a reduction in domestic support combined with the disciplines on market access and export competition in agricultural markets. The domestic support element of the simulation is structured on the July 2004 Framework, based on the assumptions outlined above. Of particular interest in simulation 6 is the interaction between the Total AMS and import tariff reductions. Improved market access for agricultural goods may lead to domestic market prices falling below the applied administered prices used to calculate the MPS component of current Total AMS in the simulation. We assume that this leads to a reduction in Total AMS by endogenously

[1] Note that the EU, USA, Canada, Japan and Brazil liberalize all three pillars. Other regions only implement market access and export competition liberalization as their domestic support policies are not modelled explicitly in this article.

lowering the level of MPS. If this happens, we recalculate the required cuts in the other elements of the base ODS and re-run the simulation.

The results from the two Three-Pillar Simulations are shown in table 4. In simulation 5, the gains to the world economy in welfare terms are valued at $30 billion. Allocative efficiency improvements are the main sources of welfare gain for the EU, Japan and Canada while, for the US and Brazil, welfare gains are driven by improvements in their terms of trade. The latter two are net exporters of many agricultural commodities and benefit from higher world prices received for their goods.

In simulation 6 the global welfare gain is reduced to $25 billion. Taking account of the degree of domestic support overhang and excluding green box measures from reduction, the size of the cuts is considerably reduced. Comparison across regions shows that the changes in welfare are not uniform. The difference can be seen in the decrease in allocative efficiency gains between simulations for the EU and US. The terms of trade benefit to the US, as a net exporter of many agricultural products, is also reduced, which contributes to the welfare change of the US decreasing by two-thirds in simulation 6 compared to simulation 5.

For the EU, the reduction in welfare from simulation 5 to 6 is approximately 30 per cent. This is due entirely to reduced gains from improved allocative efficiency, as there is a reduction in the EU's terms of trade loss, which is mainly driven by the manufactured goods sector. This sector benefits from liberalization as resources are reallocated from agricultural sectors and its output expands. The increased supply of manufactured goods reduces the price received by EU exporters on world markets. However, the fall in price is less in simulation 6 compared to simulation 5, contributing to the reduction in the terms of trade welfare loss between simulations.

That Japanese welfare remains almost unchanged confirms the relative importance of tariff cuts compared to domestic support reductions for that country. Canada's level of domestic support is low and few products have high levels of protection. Despite a relatively high degree of overhang there is little change between simulations. Most other regions see their welfare gains increasing (or losses decreasing) in simulation 6 compared to simulation 5.

Table 4 also shows an alternative decomposition of the welfare changes. Rather than decomposing the welfare results in terms of allocative efficiency, terms of trade and investment-saving effects, the results can be linked back to the initial shocks implemented in the experiment. In this case, the welfare change is decomposed into the effects of liberalizing market access, domestic support and export subsidies.

As would be expected, domestic support liberalization accounts for most of the changes between simulations 5 and 6. In the former, reductions in domestic support account for 20 per cent of the total welfare gains from liberalization. This figure falls to 2 per cent in simulation 6. The improvements in market access remain almost the same in absolute terms in both simulations at $23.5 billion, or 78 and 94 per cent of the total gains in simulations 5 and 6 respectively. The contribution of the elimination of agricultural export subsidies increases from $440 million to $707 million from simulation 5 to 6 (with its contribution to the total welfare change increasing from 1.5 to 3 per cent). This decomposition also confirms the importance of the contribution of improved market access to welfare gains in Japan and the EU (and export subsidy elimination in the latter's case).

Table 4. Welfare Change in Simulations 5 and 6
(Millions of US dollars)

SIMULATION 5	Total	Domestic Support	Market Access	Export Competition	Allocative Efficiency	Terms of Trade	Investment -Savings
EU	11,342	4,160	4,709	2,473	12,789	-1,508	62
USA	3,333	2,421	961	-50	1,028	2,378	-74
Canada	843	391	499	-47	528	314	0
Japan	5,929	-376	6,772	-468	7,184	-1,329	73
Brazil	1,553	535	984	34	120	1,348	86
Australia/New Zealand	1,152	327	488	336	-60	1,231	-20
Rest of Mercosur	594	308	225	61	79	534	-19
EBA Countries	-243	-98	31	-176	350	-545	-48
China	287	-348	728	-93	454	-135	-32
Rest of the World	5,345	-1,231	8,206	-1,631	7,684	-2,310	-29
World Total	30,133	6,090	23,604	440	30,156	-22	0

SIMULATION 6	Total	Domestic Support	Market Access	Export Competition	Allocative Efficiency	Terms of Trade	Investment -Savings
EU	8,011	468	4,703	2,840	8,284	-314	41
USA	1,007	164	900	-56	-116	1,003	121
Canada	509	50	502	-44	511	0	-2
Japan	6,340	-57	6,873	-475	7,266	-958	31
Brazil	987	62	893	32	88	844	55
Australia/New Zealand	897	52	503	342	-58	973	-18
Rest of Mercosur	307	21	223	63	49	270	-12
EBA Countries	-134	29	22	-186	380	-475	-39
China	637	16	718	-97	589	130	-81
Rest of the World	6,372	-15	8,099	-1,712	7,953	-1,485	-97
World Total	24,933	790	23,436	707	24,944	-11	0

Source: GTAP model simulation results.
Note: Welfare is measured as equivalent variation in millions of US dollars.

The final aim of simulation 6 is to observe the interaction between domestic support liberalization and improved market access via the reduction in import tariffs. It is possible for a reduction in a tariff or export subsidy to reduce the domestic market price of a commodity to a level below its applied administered price. However, this has not occurred in this simulation. The changes in market prices are not sufficient to reduce market prices below the applied intervention prices for any of the market price supported commodities in any region. For most commodities the change in price is less than 1 per cent in the EU and the US. This suggests that these tariffs contain a good amount of water, and that the effect of even a significant reduction in applied tariffs may have a relatively limited effect on producer prices in these regions.

CONCLUSION

This article provides an analysis of the implications of domestic support disciplines as part of further agricultural trade liberalization. Three major issues are addressed, the degree of domestic support overhang, the distinction between the agricultural boxes and the incorporation of the MPS component of the AMS. Two series of experiments are run using the GTAP model. One illustrates the effect of successively introducing improvements in the way domestic support reductions are modeled in liberalization simulations. The second examines the interactions between stricter disciplines on domestic support and market access and export competition.

The results suggest that more accurate modeling of domestic support reduces the estimated impact of likely disciplines. Comparing simulations 5 and 6, the gain in total global welfare is reduced by 20 per cent between the simulations, with even larger reductions for some regions such as the US or EU. The contribution of domestic support reductions to global welfare change from agricultural liberalization is reduced from 20 per cent to 3 per cent. These results, although based on illustrative improvements in market access, show that the impact of trade liberalization from stricter WTO disciplines on domestic support measures is likely to be quite small. This confirms the finding of papers such as Burfisher (2001), Hoekman *et al*. (2004) and Hertel and Keeney (2005). The major gains from further agricultural liberalization are expected to come from reductions in agricultural tariffs and other measures to improve market access. This article shows that the effect of domestic support reductions is likely to be even smaller than previous research suggests.

Comparing simulations 1 through 4 gives insight into which elements of the domestic support modeling are most likely to account for its diminished importance. Taking account of domestic support overhang and the distinction between the boxes plays a role, with the latter turning out to be more important in practice – this is partly because our experiment includes the decoupling of direct payments in the EU as part of the baseline. This is assumed to place a large proportion of the EU's direct payments into the green box. Taking into account the possibility of meeting Total AMS reduction targets by lowering MPS could be an even more significant factor in eroding the trade-creating effects of domestic support disciplines. Lowering administered support prices without any change in the protection provided to farmers through continued high tariff protection reduces the effectiveness of domestic support disciplines by a corresponding amount. The confusion created by including both forms of producer support in a single indicator, and the potential this creates for undermining domestic support disciplines, has been noted by a number of authors (de Gorter and Cook 2005).

Three further points can be made about these conclusions. First, treating direct payments as a policy wedge ignores any eligibility criteria which may influence the production response to the payments (e.g., land set-aside for arable payments or stocking rate restrictions for animal premia in the EU in the pre-Single Farm Payment era). To the extent that these eligibility criteria dampen the production response to amber or blue box payments, this reinforces the conclusion that their reduction will have only limited effects on world markets. Second, our simulations assume decoupled payments have no impact on production. Although a number of ways in which decoupled payments could influence farmers' incentives to produce have been identified in theory, the magnitude of these effects in practice is uncertain (FAO 2004; Goodwin and Mishra 2006). To the extent that decoupled payments are assumed to have an output response, this would further dampen the output, price and welfare effects in practice of tightening domestic support disciplines if it led countries to substitute green box for amber or blue box payments. Third, developing countries, in particular, have been critical of the possibility of "box shifting", arguing that giving farmers money, even if unrelated to production, will influence the amount produced. If the classification of decoupled measures as green box were challenged, or the criteria for green box measures tightened, then this would increase the importance of domestic support disciplines beyond that set out in this article.

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APPENDIX 1: CONSTRUCTION OF THE DOMESTIC SUPPORT DATASET

This appendix describes the construction of a domestic support dataset for five regions: European Union, United States of America, Japan, Canada and Brazil. Detailed information on the support provided by these regions to their agricultural producers is assembled. This information is then linked to the support provided to agricultural producers as represented in the GTAP database.

Member countries annually notify the WTO of their current levels of domestic support. These notifications are the primary data source used in this study, other than the GTAP database itself. They are used to assemble a domestic support dataset for the five regions listed above (the exchange rates used to reconcile the different notifications are shown in table A1).[1] Although for some of these countries more recent figures are available, notifications for the year 2001 are used to compare with the current GTAP database (2001 is the base year of the version 6 database).[2]

[1] We consider an EU of twenty seven members in this article. Figures for the EU27 are based on the assumption that commitments for the enlarged EU are the sum of those for the old EU15 and the twelve new members.

[2] For 2001, the EU15 reports as a single entity. Those countries that acceded to the EU in 2004 reported separately. Among EU countries, the most recently available year for Malta and Latvia is 2000. No figures are available for Lithuania. WTO (2005) is also used in case of missing data for some regions.

Table A1. Exchange Rates for 2001

	1 United States dollar =
Bulgarian lev	2.185
Cypriot pound	0.643
Czech koruna	38.035
Estonian kroon	17.538
Hungarion forint	286.494
Latvian lats	0.628
Lithuanian litas	4
Maltese lira	0.676
Poland zloty	4.104
Romanian leu	29060.8
Slovak koruna	47.795
Slovenian tolar	242.75
Euro	1.1175
Canadian dollar	1.5488
Japanese yen	121.53

Source: CIA (2006).

Domestic Support in the Five Regions

Table A2 summarizes the total value of current domestic support in each of the five regions, broken down into amber, blue and green boxes (as defined in the main body of the article). The amber box is further disaggregated to show the separate contributions of market price support (MPS), direct payments coupled to production and non-product specific support. Bound and current Total Aggregate Measure of Support (AMS) are shown and the degree of overhang is calculated. Base Overall Distorting Support (ODS) is the sum of trade distorting support, defined (in the July 2004 Framework) as the sum of final bound Total AMS, permitted *de minimis* (both product and non-product specific) and the agreed level of blue box support (defined as the higher of existing blue box support or the 5 per cent cap). We define current ODS as the sum of current Total AMS, current *de minimis* and current blue box support. Comparison of current and base ODS provides a measure of ODS overhang.

Several issues should be noted in regard to table A2. First, as indicated in the table, the green box figures for Brazil also include payments to development programs, which are excluded from reduction commitments under special and differential treatment for developing countries under Article 6.2 of the Agreement on Agriculture. These payments were valued at $332 million in 2001. There are no eligibility restrictions on the trade distorting impact of Article 6.2 support, and hence it may be in reality more trade distorting than green box support. However, we treat this support as green box support to maintain consistency with the construction of the GTAP database.

Second, for the EU, product specific Equivalent Measurement of Support (EMS) is considered equivalent to AMS.[1] All figures for AMS are the sum of EMS and AMS. The table shows the sum of total AMS across all commodities.

[1] EMS measures the value of policies extended to producers that cannot be calculated based on the method used for AMS (Goode 2003). Of the five countries examined in this article, only the EU makes use of this measure.

Table A2. Levels of Domestic Support in 2001 (Millions of US Dollars)

	EU		USA	Canada	Japan	Brazil
	Pre-Baseline	Post-Baseline				
Value of Agricultural Production [a]	238,571	238,571	198,503	21,632	73,077	38,409
Bound Total AMS	65,383	65,383	19,103	2,777	32,691	954
Market Price Support	25,492	22,638	5,826	295	3,242	0
Direct Payments	10,905	10,905	8,802	349	2,379	236
Non-Product Specific Support	1,372	1,372	6,828	1,346	165	740
AMS (product & non-product specific)	37,769	34,914	21,456	1,990	5,785	976
De Minimis	2,000	2,000	7,043	1,513	264	976
Current Total AMS	35,769	32,916	14,413	477	6,049	0
Degree of Total AMS Overhang[5]	45%	50%	25%	83%	81%	100%
Blue Box ($ Millions)	21,261	2,640	0	0	749	0
Blue Box (% of value of production)	9%	1%	0%	0%	1%	0%
Green Box	19,452	40,414	50,672	1,108	21,023	1,794
Of which: Development Box [b]	-	-	-	-	-	332
Base Overall Distorting Support [c]	110,502	101,169	48,879	6,022	76,537	6,715
Current Overall Distorting Support [d]	59,030	37,556	21,456	1,990	7,062	976
Overall Distorting Support Overhang [e]	47%	63%	56%	67%	91%	85%

Source: Notifications to the WTO (Various) and own calculations

Note a: Value of production is the sum of production reported in the notifications of each region.

Note b: we treat the "Development Box" in a similar way to green box support.

Note c: Base ODS is the sum of bound Total AMS, permitted *de minimis* (both product specific and non-product specific) and agreed level of blue box support.

Note d: Current ODS is the sum of current Total AMS, current *de minimis* (both product specific and non-product specific) and current blue box support.

Note e: Overhang is the difference between current and bound/base levels, expressed as a percentage of the bound/base total.

Third, for the EU and Japan, the calculation of the *de minimis* threshold level requires data on the value of production for each commodity. For the majority of commodities the production value is provided in the notifications. However, for these two regions the production values for some commodities are not reported. Data are taken from EAGGF reports (EC 2003) and the OECD (2002a) to supplement the notifications.

Finally, the figures for the EU are reported for pre- and post-baseline. The construction of the baseline pre-experiment is described in the article. The policy changes modeled in the baseline that are of relevance to the domestic support dataset are the reforms of the EU's

Common Agricultural Policy (the completion of the Agenda 2000 reform and the implementation of the Mid-term Review in 2003).

The baseline is implemented in the GTAP model and in the domestic support dataset. From the perspective of the domestic support dataset, the baseline involves several changes, the effects of which can be seen in the differences between the domestic support figures for the EU. MPS in reduced for some products. To compensate producers for these reductions, direct payments are increased. The major element of the Mid-term Review is the decision to decouple a large share of direct payments from production, thus allowing them to be shifted from the blue box to the green box. As table A2 shows, the result of this is to increase the EU's degree of Total AMS and ODS overhang.

Linking the Domestic Support Dataset to the GTAP Model and Database

As noted in the main body of the article, domestic support in GTAP is represented as four categories of subsidies: output, intermediate input, land-based and capital-based subsidies. Table A3 shows the total value of domestic support in the GTAP database and the breakdown into these four subsidy categories.

A comparison of data from the WTO notifications and the GTAP database in tables A2 and A3 shows considerable differences. The main source of the differences in trade distorting support arises from the exclusion of the MPS component in GTAP.[1] In addition, whilst a substantial share of green box measures is represented in the database, others are excluded leading to another source of the differences between the figures.[2]

Table A3. Domestic Support in the GTAP Database (Pre-Baseline - Millions of US Dollars)

	EU	USA	Canada	Japan	Brazil
Total	44,103	32,548	2,486	4,580	496
Output Subsidies	3,800	9,537	263	1,465	496
Intermediate Subsidies	5,349	6,995	270	972	0
Land-based Payments	20,955	15,588	1,863	974	0
Capital-based Payments	13,999	428	90	1,169	0

Source: the GTAP Database.

The dataset must be linked to the GTAP model and database to use it in running simulations. Clearly, given the differences between the two, a perfect match is not possible However, based on the documentation of the GTAP database and other sources and certain assumptions, it is possible to classify the support in the GTAP model into amber, blue and green boxes. It is important to note that our approach takes the support in the GTAP model as given, so we do not attempt to change the model database. The support which is shown in

[1] Domestic support in the model and database is based on the OECD's PSE categories B to H. MPS (category A) is not included in GTAP, other than an implicit representation through border protection.

[2] For example, a measure excluded as it is classified in category R in the OECD database is domestic food aid and assistance programs in the US which are valued at over $10 billion in 2001.

GTAP is assigned to the boxes based on best estimates of the domestic support instruments which it represents.

The first step is to aggregate the AMS for each region to the GTAP commodity level. Data on AMS (direct payments and MPS) is provided in the notifications for a range of commodities, usually between twenty and thirty. However, there are only twelve primary agricultural commodities in GTAP. This aggregation of the notification data gives a measure of AMS at the GTAP level of aggregation.

To aggregate MPS, average applied administered prices and external reference prices are calculated for GTAP sectors. Production tonnages are used as weights to calculate the average prices. For commodities with no MPS, the applied administered price is set to zero. As part of this aggregation process, non-product specific support for a country is distributed across the agricultural sectors of each region based on value of production. It is modeled as direct payments in the form of output subsidies to each commodity. A similar process is undertaken to assign the blue and green box support data from the WTO notifications to the GTAP aggregation of products.

These figures for amber, green and blue box domestic support for each commodity are then compared to the support reported in GTAP for those commodities. Based on Jensen (2006) and Young *et al*. (2002) the subsidies in GTAP are then allocated to the boxes. Jensen provides the allocation of PSE commodities to the GTAP subsidy categories used in the construction of the database for EU members. Given this, it is possible to allocate the output, export, intermediate and land and capital based subsidies to the boxes. For the other regions examined here, this process is simplified as they did not make use of the blue box in 2001 (with the exception of payments to rice producers in Japan). Young *et al*. provide a classification of subsidies that further aids this process. The resulting allocation is shown at the end of table A4.

In implementing the simulations of domestic support liberalization in this article, the required support reductions are first calculated outside of the model, in the domestic support dataset, to avoid an aggregation bias.[1] The data are then aggregated to the level of the agricultural sectors in GTAP to produce estimates of the required changes to current Total AMS, blue box and green box support for each sector.

[1] Consider a simple example. Barley: AMS = €8; Production = €100. AMS exceeds the *de minimis* threshold and is included in Total AMS. Rye: AMS = €1; Production = €100. AMS falls below the threshold and is therefore excluded from Total AMS. When these are treated as separate commodities, Total AMS is equal to €8. However, if barley and rye are aggregated to create a new cereals sector: AMS = €8+€1; Production = €200. AMS now falls below the *de minimis* threshold and therefore Total AMS is €0.

Table A4. Classification of GTAP Domestic Support to the Amber, Blue and Green Boxes (Pre-Baseline - Millions of US Dollars)

		EU	USA	Canada	Japan	Brazil
Amber Box	Output Subsidies	3,653	8859	249	414	481
	Intermediate Subsidies	4,958	6567	205	867	0
	Land-based Subsidies	103	486	403	907	0
	Capital-based Subsidies	905	392	84	989	0
	Total	9,619	16,304	941	3,177	481
Blue Box	Output Subsidies	0	0	0	750	0
	Intermediate Subsidies	56	0	0	0	0
	Land-based Subsidies	16,715	0	0	0	0
	Capital-based Subsidies	7,144	0	0	0	0
	Total	23,915	0	0	750	0
Green Box	Output Subsidies	147	678	14	301	15
	Intermediate Subsidies	335	428	65	105	0
	Land-based Subsidies	4,137	15102	1460	67	0
	Capital-based Subsidies	5,950	36	6	180	0
	Total	10,569	16,244	1,545	653	15

Source: GTAP Database, Notifications to the WTO (Various) and own calculations.

APPENDIX 2: EXTENSION OF THE GTAP MODEL

The standard GTAP model is extended to incorporate an explicit representation of the MPS element of the AMS. The inclusion of the value of market price support, summed together with the appropriate, non-exempt direct payments, enables the calculation of AMS in the model. The first section of this appendix briefly outlines the MPS mechanisms used by different countries. The second section describes the extension of the GTAP model.

Market Price Support Mechanisms

We focus on MPS programs that operate by maintaining an administered price above the world market price. Not considered are price support programs in which governments pay producers the difference between market prices and administered prices (e.g., US deficiency payments programs). Under the WTO classification, such programs are included in the direct payment component of AMS, not the MPS component.

MPS programs function by providing a guaranteed price to producers (the applied administered price). The value of MPS is measured by multiplying the difference between the applied administered price and an external reference price (fixed at a historical base period 1986-1988) by the tonnage of eligible production.[1] For these programs to be effective and support agricultural producers, the administered price must be kept above the world market

[1] This methodology differs from the OECD's calculation of the value of market price support measures in their Producer Support Estimates (OECD 2002b). The PSE market price support is measured as the difference between domestic market prices and border prices. The PSE definition of market price support is based on market price data, it measures the actual value of support, rather than the WTO definition based on the applied administered price and fixed external reference price.

price. This is achieved via a range of domestic restrictions and trade barriers, the exact mechanisms employed vary from country to country. Of the five regions analyzed in this article, four report MPS in their notifications to the WTO in 2001 (the value of support in Brazil in 2001 is zero).

The EU provides price support to over a dozen commodities in 2001, primarily cereals but also beef, sugar and some dairy products. The applied administered price is the intervention price at which the EU is obliged to purchase the commodity should be market price fall below it. The intervention price acts as a price floor. The domestic market price is kept above world market prices by import tariffs and non-tariff barriers that restrict foreign supply to the internal market, as well as by subsidizing exports. For a detailed description of EU (and US) domestic support policies, see Gopinath *et al.* 2004.

The US provides MPS to three commodities (dairy, peanuts and sugar) via a price support / quota system. Producers receive a guaranteed minimum price (e.g., in the case of sugar this is enabled by a system of non-recourse loans) and tariff rate quotas (TRQs) are used to restrict competition from abroad. The out of quota tariff is set sufficiently high as to be prohibitive. TRQs are not explicitly represented in the GTAP database. However, TRQs are incorporated in the import tariffs in the database. Tariff data in GTAP are constructed using the MAcMap dataset (Dimaranan and McDougall 2006).

Japan provides MPS to wheat, barley, sugar, beef and veal, pigmeat and some vegetables in 2001. The mechanisms used for these commodities vary. For example, the government purchases wheat and barley at a guaranteed price and resells at a lower price (this policy has been reformed since 2002). Although this support involves a budget outlay and is notified as a direct payment, there is also an element of price support. High prices are maintained by TRQs, which restrict in-quota purchasing to only the Food Department of Ministry of Agriculture, Forestry and Fisheries. For sugar producers a MPS system offers them a minimum guaranteed price (with all imports of sugar purchased by a government firm).

Finally, in Canada butter and skimmed milk products receive MPS. This is provided by a system of support prices. The Canadian Dairy Commission buys and sells dairy products at established support prices. The difference between this price and the external reference price, multiplied by the eligible production, in this case total production, measures the value of MPS offered to Canadian producers. High market prices are ensured by TRQs that allow only small levels of imports, with extremely high out of quota tariffs.

Extension of the GTAP Model

MPS is not explicitly included in the standard GTAP model and database. As the previous section illustrates, import barriers play a key role in maintaining prices above world market levels and MPS is considered to be implicitly included in the model via the border protection rates. In this article, the model is extended to make this representation of MPS more explicit.

To begin, the applied administered prices and the external reference prices are introduced to the model as new variables. A new sub-set (category of commodities) is created of the agricultural commodities that receive MPS. If a commodity does not receive any support in a region then these prices are set to zero.

For the two new prices to be meaningful, their values are adjusted relative to the prices in the model (all prices in the model are initially equal to one as is typically the case in CGE models). Consider the case of common wheat in the EU. The producer or farm gate price is €118/t and the administered price is €101/t (these are post-Agenda 2000 reform prices). If the initial market price in the model is 1, the adjusted relative administered price is 0.85. The same calculation is followed for the external reference price. The domestic market price received by producers in the model is assumed to be equivalent to the producer price as reported by the OECD (2002a). The applied administrative prices can be adjusted as part of a simulation which requires a reduction in the MPS component of a country's current Total AMS.

The existing level of protection in GTAP does not change. There are no changes in prices as a result of the introduction of these new variables. The cost of MPS is borne by consumers via higher prices, rather than by increased government outlays. These higher prices are assumed to be implicitly included in the price levels in the database.

The link between applied administered prices and producers is introduced to the model via a complementarity function (Harrison *et al*. 2002). The complementarity function is a feature of the GEMPACK (Harrison and Pearson 1994), the software that is used to implement the GTAP model. It allows CGE models containing inequality constraints or non-differentiable functions to be solved.

The complementarity function compares the applied administered price (adjusted if appropriate depending on the simulation) to the market price. As a result of a simulation, market prices will fluctuate endogenously. Should this fluctuation take the market price below the administered price for that commodity, this triggers the complementarity function. Once the market price goes below the administered price, this is assumed to result in a cut in the latter to the new level of the market price. This reduces the level of support provided to that commodity.

This approach makes an explicit assumption about the reaction function of policy makers. To take the EU as an example, if the market price falls below the administered price (which is the intervention price), this would lead to a build up of stocks to unsustainable levels. We make the assumption that policy makers react by lowering the intervention price.

As noted in the previous section, import protection is used to underpin the MPS mechanisms in all the regions studied in this article. If import tariffs are reduced in this extended version of the GTAP model, domestic market prices fall (depending on the value of the Armington elasticity between imported and domestic goods), which may result in the price going below the applied administered price. In general, the converse does not hold. If the administered price is lowered without any change in border protection, there is no reason why the effective support price to farmers should change. For example, Japan removed MPS to rice producers in 1998 but import barriers maintain domestic prices at previous levels (Hart and Beghin 2005). For this reason, the way in which we model the choice between reducing direct payments and reducing MPS in the amber box in the article represents the maximum possible leverage of domestic support disciplines. If governments chose to meet more stringent ODS and AMS disciplines by simply lowering or eliminating administered prices, then the impact of these disciplines would be further attenuated compared to the results shown in the article.

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VALUING PRIVATE SECTOR INCENTIVES TO INVEST IN FOOD SECURITY MEASURES: QUANTIFYING THE RISK PREMIUM FOR ALTERNATIVE TRACKING SYSTEM

William Nganje[1], Bruce Dahl[2], William Wilson[2], Mounir Siaplay[3] and Andrew Lewis[4]

[1]Morrison School of Management and Agribusiness,
Arizona State University , Mesa AZ USA
[2]North Dakota State University, Department of
Agribusiness and Applied Economics, ND USA
[3] Department of Agricultural Economics, Oklahoma State University, OK USA
[4] Risk Management Agency, USDA, Topeka, Kansas USA

ABSTRACT

Increased risks associated with bioterrorism have important implications for many industries, particularly the food system. In December 2004, the Food and Drug Administration (FDA) issued a Final Food Bioterrorism Regulation for establishment and maintenance of records to track commodity flows one-step forward and one-step backward (OSF/OSB) for all firms along the food supply chain, including international food suppliers. Any regulation adopted to mitigate risks involves costs that may have significant trade implications. We use stochastic optimization models to analyze firm-level costs and incentives for a vertically integrated firm in the wheat supply chain to invest in three alternative tracking systems: the OSF/OSB Regulation, radio frequency environmental monitoring (RFEM) systems, and random testing. Models are constructed representing domestic and export supply under risk and uncertainty. Results indicate tracking with RFEM systems is more cost-effective than tracking with OSF/OSB Regulation for the export and domestic markets. Moreover, tracking with RFEM provides real time monitoring and alleviates adverse trade concerns from regulation.

Keywords: Food terrorism regulation, radio frequency environmental monitoring, trade implications, cost-effectiveness, wheat supply chain.
JEL Classifications: C61, Q18.

INTRODUCTION

Protection of America's agricultural production and food supply is essential to the health and welfare of both the domestic population and the global community [U.S. Department of Agriculture (USDA), 2004]. Unofficial estimates place economic losses in the United States from the attacks on September 11, 2001 at $2 trillion (U.S. Department of State, 2002).[1] Food terrorism, and in particular terrorist acts occurring in the grain supply chain, is a relatively new concept (Nganje, Wilson, and Nolan, 2004). In the past, terrorist attacks were largely focused on people and their properties. Today, food constitutes one of the most vulnerable sectors to intentional contamination by debilitating agents (World Health Organization, 2002)[2]. Contamination of food by terrorists poses a real and current threat, and food contamination at one location could have global trade and public health implications (Lyonga et al., 2006).

The United States is a major producer of small grains (wheat, barley, corn and soybeans). From 1999-2003, U.S. exports as a percentage of production averaged 50 percent for wheat, 12 percent for barley, 19 percent for corn, and 37 percent for soybeans (USDA-Economic Research Service, 1999-2003). If there is any tampering by terrorists of U.S. grains and oilseeds, it may cost the United States billions of dollars due to trade disruptions, effects on public health, usage of these products as inputs in other industries, and decreased consumer confidence.

To address concerns of food terrorism, the Food and Drug Administration (FDA) issued a Final Food Bioterrorism Regulation for establishment and maintenance of records to track commodity flows one-step forward and one-step backward (OSF/OSB) in December 2004 (Federal Register 21, Subpart J). This Regulation affects firms that manufacture, process, package, transport, distribute, receive, store, or import food into the United States. Compliance dates were December 9, 2005 for large firms; June 9, 2006 for small businesses with fewer than 500 employees; and December 11, 2006 for very small firms with fewer than 10 employees. In addition to tracking records (names, origins, destination points, date shipment was received and date released, number of packages, etc.), the Regulation stipulates that establishments will maintain records already required for two years. For the grain industry, records already required include random testing and maintenance of grain quality data. This Regulation is anticipated to increase security and solidify processes by tracking commodity flows along the supply chain to minimize food terrorism risks. However, issues relating to firm-level costs, incentives to invest in security measures, and potential trade implications of this Regulation have yet to be investigated.

Foreign governments and international trade associations agree in principle to the recordkeeping requirement of the OSF/OSB Regulation provided it is based on sound risk

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[1] Due to the growing threats of terrorism against the United States both domestically and internationally, President Bush signed into law in January 2002, the Defense Appropriations Act. According to the USDA-FSIS (2005), of the $328 million in emergency funding for the USDA to further protect the public by strengthening essential programs and services related to biosecurity, $16.5 million is for security upgrades and bioterrorism protection. Of this amount, $10 million is allocated to conduct a food safety bio-terrorism protection program.

[2] When U.S. troops entered the caves and safe houses of members of the al Qaeda terrorist network in Afghanistan in the months following the September 11th attacks, they found hundreds of pages of U.S. agricultural documents that had been translated into Arabic. A significant part of the group's training manual is reportedly devoted to agricultural terrorism-specifically, the destruction of crops, livestock, and food processing operations (Peters, 2003; Risen and Van Natta, Jr., 2003).

assessment and does not restrict trade more than necessary (FDA-Final Rule, Comment 14, p. 71570). Comments about the regulation suggest that the compliance cost may adversely affect international trade flows and may lead to the unintended consequence of foreign countries imposing similar requirements on U.S. exports to their countries.

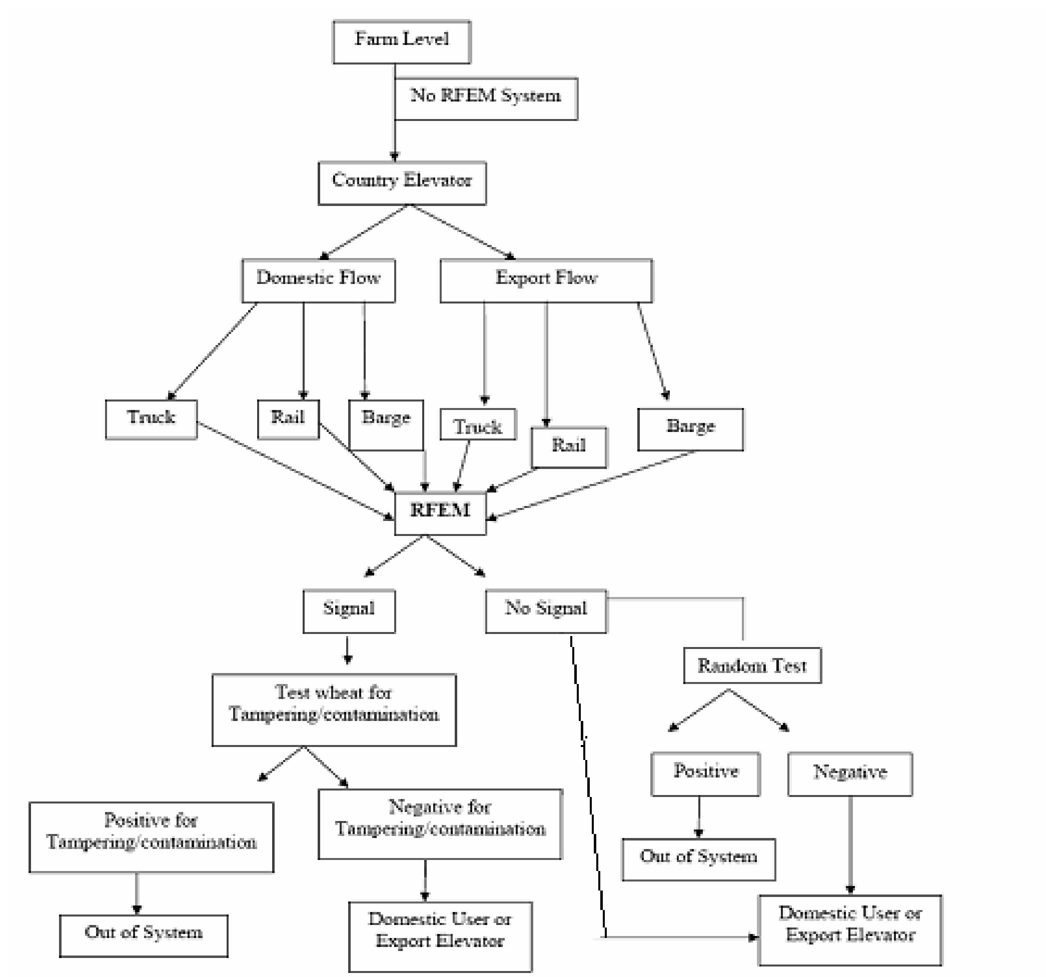

Figure 1. Vertically Integrated Firm in the Wheat Supply Chain.

We use stochastic optimization models to determine optimal testing and sampling strategies and to analyze costs and risk premiums for a vertically integrated firm[1] (figure 1) in the wheat supply chain to invest in alternative food security measures or three alternative tracking systems: the OSF/OSB Regulation; radio frequency environmental monitoring

[1] Vertical integration is a common practice in grain production with organizations like farmer owned cooperatives having ownership and control over the production and marketing of grains. Using this form of coordination to model the cost-effectiveness of tracking methods and to minimize food terrorism risks enables us to provide comparable system costs, net revenues, and risk premiums for all participants along the grain supply chain and avoid the "hold-up problem." The hold-up problem is a situation where agents along the grain supply chain may be able to work most efficiently by cooperating, but refrain from doing so due to concerns that they may give other agents increased bargaining power that may reduce their own profits and/or expose themselves for liability if problems are traced back to them.

(RFEM) systems or tracking with smart seals; and random testing. The risk premium is the incentive required by the firm to offset potential risks from a food terrorism attack when they invest in security measures. It is a measure of the value of risk reduction of alternative tracking systems. The stochastic optimization models developed in this paper have the added flexibility to incorporate multiple risk factors. Anther contribution of this study is that it provides a framework to quantify the benefits of evolving technology like RFEM, a technology similar to radio frequency identification devices (RFID). It is hypothesized that tracking with the RFEM system is more cost-effective compared to tracking with the OSF/OSB system, since testing costs are incurred only when tampering with smart seals occurs. The next section gives a detailed description of the three alternative tracking systems or strategies.

Description of Tracking Strategies

The three tracking systems that are compared in this study are random testing (base case), tracking with RFEM systems, and tracking with the OSF/OSB Regulation. Random testing is the traditional method to collect grain quality data (e.g., test weight, protein content, etc.) and the level of chemicals or toxins (e.g., DON – a toxin from scab-infested grains). As grain moves along the supply chain (farmer, truck, receiving elevator, rail, export elevator, shipper, and end-user) random tests are performed to track quality and ensure conformance to buyer specifications. This traditional tracking approach is associated with testing costs and buyer and seller risks of meeting grain quality specifications (Wilson and Dahl, 2005). Random testing serves as the base technology for the RFEM and OSF/OSB systems.

A second approach analyzed in this study is tracking with RFEM technology, comparable to a home security alarm system. In recent years, electronic monitoring devices (ID) like RFEM have emerged as an alternative tracking device to prevent food terrorism (Thompson, 2004). The market for digital inventory tracking systems and personal ID systems (like RFID and RFEM) are expected to expand from $2.7 billion in 2006 to as much as $26 billion in 2016 (Newitz, 2006). ID systems can be passive or active emitters (with writable memory area) and are used widely in library systems, tracking of product shipment and inventory management, car starters, automatic toll paying, etc.

When container seals are equipped with RFEM alarm systems, testing of grain loads is required only if the alarm signals tampering. Otherwise, only random testing is performed. RFEM systems are different from RFID systems as they can be used for measuring, recording, and transmitting real time data on environmental variables such as temperature, relative humidity, carbon dioxide, and oxygen concentration (Thompson, 2004). The writeable memory area on the device can be encrypted or locked to prevent data tampering, but this raises the cost from approximately $0.25 to $5 per tag. Commercial ID systems produced by Tagsys, Texas Instruments, and other manufacturers are not encrypted because it becomes too costly to use them on smaller unit items. However, the use of RFEM systems in bulk transportation, as smart seals, may be cost-effective.

Uncertainties related to costs and efficacy limit industry and firm use of these technologies. With recent advancements in the stochastic optimization framework, we can simulate the costs and the value of risk reduction or the risk premium associated with the

RFEM technologies for alternative uses. The stochastic optimization method also provides an effective approach to quantify the market value of emerging technologies like the RFID and RFEM. In the model section, we present this approach in detail and use it to compare the costs and risk premiums of alternative tracking systems.

A final strategy analyzed in this study is tracking for bioterrorist events with OSF/OSB food terrorism Regulation. This new Regulation will require all agents to track grain data one step forward and backwards. For the grain sector, this implies testing and keeping records for two years by each firm along the supply chain, as required by the Regulation.

THE MODEL

The stochastic optimization model of grain flows in the handling system reflecting the structure of tracking and testing for toxins and chemicals along the supply chain is used to determine the aggregate tracking cost, buyer and seller risks, and the risk premium (Saha, 1993; Wilson and Dahl, 2006). Trade implications are derived from comparing alternative tracking systems costs, buyer, and seller risks. Tests can be conducted at different stages (from the farm to the end-user) and at varying sampling intensities to determine acceptable levels of toxins (e.g., less than 1ppm for DON, a toxin from Fusarium Head Blight infected grains), chemicals, and other grain quality attributes. The model chooses the optimal testing strategy (where to test and frequency/intensity) that maximizes the expected utility of the certainty equivalent for each tracking strategy. The risk premium is derived for alternative tracking systems as the expected returns of the base case strategy (random testing) less the certainty equivalent of the OSF/OSB and the RFEM systems.

$$\pi_i = EV_{BCM} - CE_i, \tag{1}$$

where: π is the risk premium; i is tracking with OSF/OSB or RFEM systems; EV_{BCM} is the expected value of the base case model with random testing; and CE is the certainty equivalent of the alternative system for which you want to estimate the risk premium (either the tracking with food terrorism regulation or with RFEM systems). Estimating the CE requires assumption of the firm's risk preference. We adopted the approach by Saha (1993), where an expo power utility function is used to maximize the expected utility of the certainty equivalent (equation 2). The objective is:

$$MaxEU(CE) = E(\lambda - e^{(-\Phi NR^{\eta})}) \tag{2}$$

$$\text{s.a.} \qquad X_j \in Y_j ,$$

where: U is utility; CE is the certainty equivalent of the vertically integrated firm in the wheat supply chain; λ is parameter determining positiveness of the function; E is expectation; e is the exponential function; Φ and η are parameters which affect the absolute and relative risk aversion of the utility function; X_j is the decision variable vectors of the model (whose elements are T_{ij} and S_{ij}, representing where to test and how intensive to test); Y_j is the opportunity set of the model; and NR is the net revenue function (revenue minus system cost).

In this model, the total system or aggregate cost is estimated for each strategy. Costs are estimated for tests conducted at each stage separately. The total system cost (C_i) is defined as

$$C_i = \sum_{j=1}^{n} T_{ij} * TC_{ij} * S_{ij} * V_{ij} + Q * L_{ij} + RFEM_{ij} , \tag{3}$$

where: i represents alternative tracking approaches (random testing, tracking with RFEM, and tracking with OSF/OSB); j is the location where tests are conducted;[1] T_{ij} is a binary variable indicating test/no test at location j; TC_{ij} is the cost of testing per unit ($/test) at location j; S_{ij} is the sampling intensity at location j; V_{ij} is the size of shipment at location j; Q is the volume diverted (quantity not meeting specifications) multiplied by quality loss cost (L_{ij}) per unit at location j; and $RFEM_{ij}$ is the cost of RFEM per unit multiplied by the number of RFEM units installed at location j.

The advantage of using the exponential power utility function in the simulation model is that it is flexible and allows for changes in absolute and relative risk aversion. In addition, the utility function allows us to quantify the risk premium that makes the vertically integrated firm indifferent between the risk associated with random testing only and the risks associated with RFEM and OSF/OSB tracking systems. The parameters of the utility function λ, Φ, and η are fixed to 2, 0.01, and 0.5, respectively, following Serrao and Coelho (2000) and Wilson and Dahl (2005).

DATA AND SIMULATION PROCEDURES

Parameters for the model include lot sizes for each transportation mode, the distribution of shipments (rail, truck, and barge) from country elevators to export elevators/domestic users and quality loss costs. Lot sizes at each stage in the marketing chain are 136 metric tons (mt) for on-farm testing, 22 mt for truck shipments, 90 mt for rail movements, and 900 mt for barge, shipments, ship lots, and ocean vessel shipments (Wilson and Dahl, 2005). The distribution of wheat flows (rail, truck, and barge) for shipment from country elevators to domestic users and export elevators is derived as the average percentage for each mode from 1987 to 2000 (Marathon, VanWechel, and Vachal, 2004). Shipments to domestic users are 64 percent, 33 percent, and 3 percent, and to export terminals, 57 percent, 34 percent, and 9 percent, for rail, truck, and barge, respectively (USDA-Agricultural Marketing Service, 2005). Quality loss costs are composed of the price of wheat, disposal, and cleaning costs of $152.49/mt, $9.19/mt, and $3.67/mt, respectively (USDA-Agricultural Marketing Service, 2005; Lueck et al., 2000).

Testing costs and accuracies, RFEM reliability, and the probability of contamination at each stage in the marketing chain are random and represented by distributions. Testing costs are represented by a triangular distribution with a minimum of $15, most likely of $25, and maximum cost of $35/test (Mostrum, 2005). Testing accuracies are assumed to be uniform distributions ranging between 0.9 and 1.0 (Mostrum, 2005). RFEM units cost $0.45/unit and

[1] Tests can be conducted at different stages and at varying sampling intensity at any location in figure 1 to determine acceptable levels of toxins, depending on whether the RFEM system signals tampering or not.

reliability of signaling for RFEM units is assumed to be uniformly distributed between 0.95 and 0.99 (Thompson, 2004). The probability of intentional contamination is reflected at each stage of the marketing chain by a Poisson distribution. Nganje, Wilson, and Nolan (2004) suggest that a probability of 0.01 can be assumed as the base probability over a five-year period. The size of contamination, if contamination occurred, is assumed to be equal to the lot size and introduced into the wheat flow at the point of occurrence.

The models are simulated using *Risk Optimizer* (Palisade Corporation, 1998), a software program that solves optimization problems with uncertainty. The software uses a genetic algorithm to identify the optimal testing strategy (where and how intensive to test) that maximizes the expected utility of certainty equivalent for a vertically integrated grain handling firm. Each testing strategy is simulated for 5,000 iterations. The genetic algorithm selects successive sets of choice variables until the optimal strategy is identified. The model tracks wheat flows throughout the wheat supply chain and evaluates buyer and seller risks, elements of testing, and RFEM costs. If the RFEM system signals tampering, more testing costs are incurred by the firm. If the system detects contamination, then disposal and cleaning costs are incurred by the firm. Buyer risk is the risk that product exceeding the tolerance level will get into the buyer product stream, and seller risk is the risk that product thought to be within the tolerance level will be rejected by the importer.

Sensitivities are conducted to examine the effects of critical parameters/distribution on the optimal strategies and costs/risks. These critical parameters include the probability of contamination with toxins like DON, cost of testing, accuracy of tests, reliability of RFEM, and quality loss costs.

MODEL RESULTS

Three models, representing the three tracking systems, are developed. The models are used to estimate the system costs, risks, optimal testing strategies, and to derive the risk premiums and trade implications for alternative tracking systems.

Domestic Model

The base case model depicts a vertically integrated firm in the wheat supply chain that does random testing for toxins and chemical agents like anthrax. There is no RFEM system and mandatory testing is applied on all lots arriving at the domestic user.

The optimal testing strategy for the base case is not to test at the farm level or country elevator when receiving or loading (table 1). Buyer and seller risks are minimal with mean values of 0.000000002 and 0.000006 percent, respectively. These values indicate 0.000000002 percent of lots entering domestic user flows have contamination (buyer risk) and 0.000006 percent of lots shipped to domestic users are rejected (shipper risk). Average costs for conducting random testing for chemical agents and quality loss are \$0.225/mt and \$0.001/mt, respectively. The certainty equivalent is \$0.223/mt, indicating the decision maker would require a premium of \$0.223/mt to be indifferent between the base case system and one with no testing.

In the second model, an RFEM system is utilized for rail, barge, and truck shipments transporting bulk wheat. A test is applied on all RFEM lots signaling tampering and at the domestic user for all lots not signaling tampering. The optimal testing strategy for the domestic RFEM system is not to test on farm or at the country elevator when unloading or loading (table 1). Buyer risks for the RFEM system average 0.0000066 percent, and we are 95 percent confident that mean values lie between 0.000006 and 0.000009 percent (figure 2, upper left panel). Seller risks average 0.0010147 percent with a 95 percent confidence interval of 0.0009 to 0.0012 percent (figure 2, lower left panel). With the RFEM system, buyer and seller risks, while still minimal, are larger than those in the base case.

Table 1. Domestic Wheat Model Results: Base Case, Testing with RFEM, OSF/OSB

Variables	Base Case Testing No RFEM	Testing with RFEM	OSF/OSB
Utility	1.2003	1.2003	1.2003
Test (1= yes/0= No)			
Intensity % Sampled			
On Farm Storage	0-NA[1]	0-NA	1-100%
Country Elevator Receiving	0-NA	0-NA	1-100%
Country Elevator Load Out	0-NA	0-NA	1-100%
Domestic User NSig Rail	1-100%	1-100%	1-100%
Domestic User NSig Barge	1-100%	1-100%	1-100%
Domestic User NSig Truck	1-100%	1-100%	1-100%
Domestic User Sig Rail	NA	1-100%	NA
Domestic User Sig Barge	NA	1-100%	NA
Domestic User Sig Truck	NA	1-100%	NA
Buyer Risk of Flow Cont.	0.00000002	0.0000066	0.00000015
Seller Risk of Flow Rejected	0.000006	0.0010147	0.00000661
Total Vol. Diverted	0.2023	31.2596	4.6749
Costs ($/MT)			
Cost of Testing	0.2216	0.2218	1.8327
Cost of RFEM	0	0.0039	0
Cost of Quality Loss	0.0011	0.1737	0.0253
Certainty Equivalent ($/MT)	0.2227	0.4001	1.8579
Comparison to Base		0.1774	1.6353

[1] NA is Not Applicable.

Average costs for the RFEM system for testing, RFEM tags, and quality loss are $0.222/mt, $0.004/mt, and $0.171/mt, respectively. Figure 2 (upper right panel) shows the distribution of quality loss costs in the domestic wheat flow. The results indicate the 95 percent confidence interval for quality loss costs is between $0.11/mt and $0.18/mt. Figure 2 (lower right panel) shows the distribution of total costs. The results indicate a 95 percent confidence interval for total system costs to be between $0.33/mt and $0.40/mt.

Installing an RFEM system increases the certainty equivalent to $0.400/mt. This indicates that the decision maker requires a risk premium of $0.177/mt ($0.40/mt minus $0.223/mt) to be indifferent between the RFEM system and the base case.

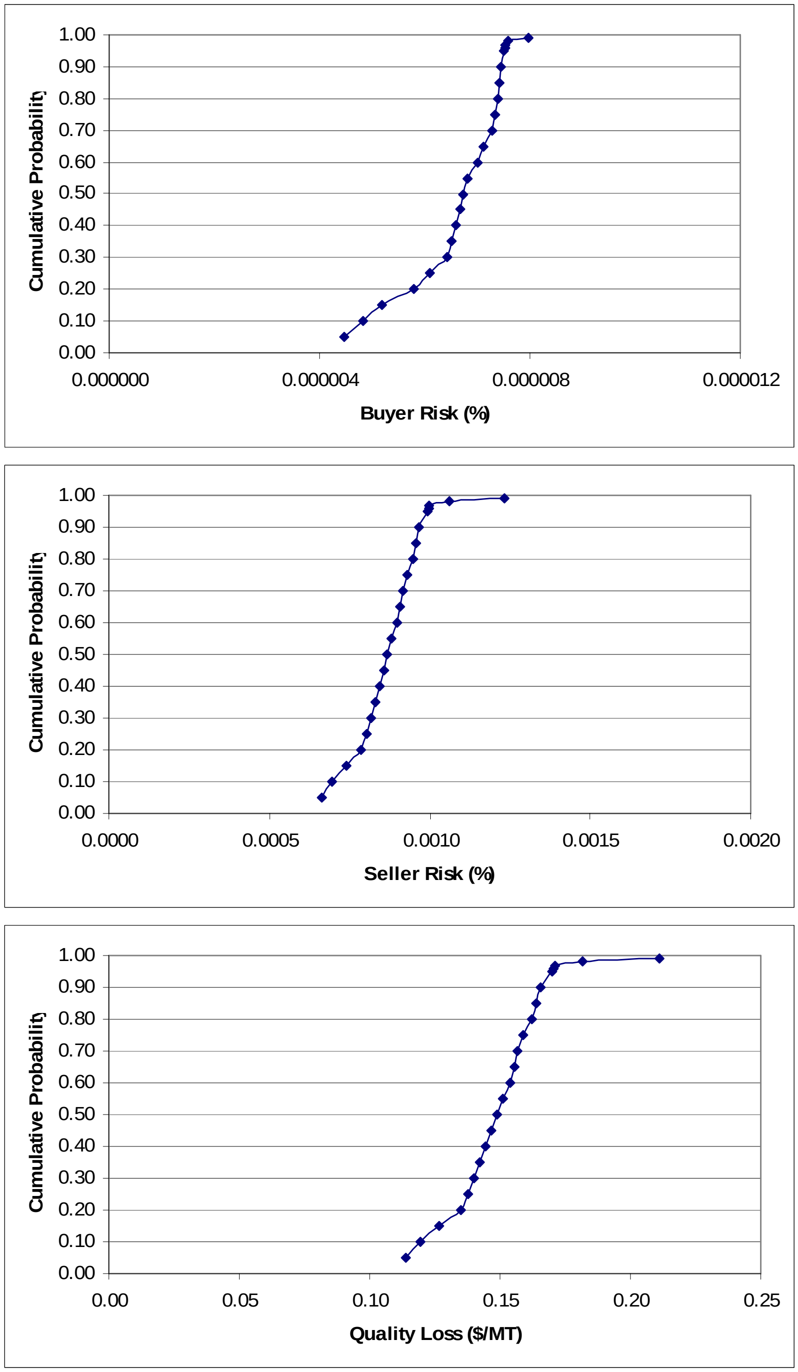

Figure 2. Continued

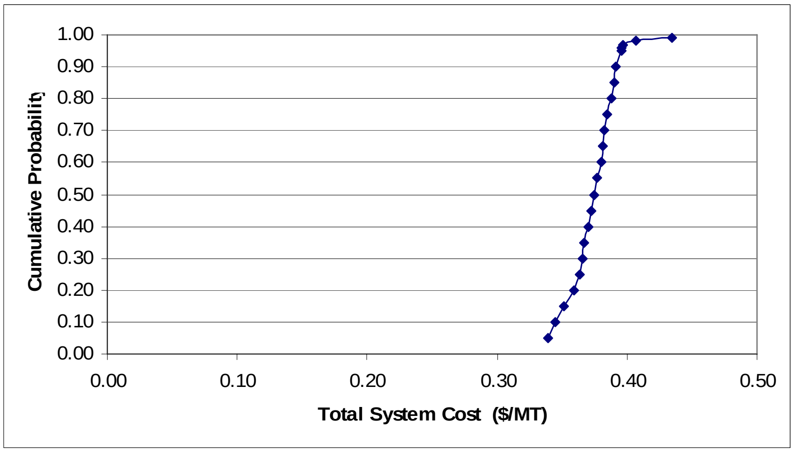

Figure 2. Distribution of Buyer Risk, Seller Risk, Quality Loss Costs, and Total System Costs, Domestic Model.

The third model simulated is one where tests are applied one step forward and one step backward. This requires tests on all lots on the farm, at the country elevator when receiving and loading, and at the domestic user when receiving. No RFEM system is utilized and there are no optional testing locations.[1] Buyer and seller risks of this system are between the base case (lower bound) and the system with RFEM (upper bound), yet are near the base case values. Average buyer and seller risks are 0.00000015 and 0.00000661 percent, respectively. Costs for the OSF/OSB system are the highest of the three domestic systems. Costs for testing and quality loss are $1.83/mt and $0.03/mt, respectively. The OSF/OSB system has a certainty equivalent of $1.858/mt, implying a much higher risk premium compared to the RFEM system. Significant trade implications are derived from comparing buyer and seller risks and the risk premium for the export model.

Export Models

The three models are also solved for export flows. The base case model depicts a vertically integrated firm in the wheat supply chain where random testing for toxins and chemical agents can be conducted at selected locations as it exist under the current system, but does not have RFEM. Mandatory testing for potential wheat contamination is conducted for all lots arriving at the importer.

The optimal testing strategy is not to test at any of the optional testing locations (table 2). The buyer and seller risks are 4.8E-7 and 1.4E-5 percent, respectively. The costs for the optimal testing strategy for conducting random testing and quality loss are $1.148/mt and $0.00002/mt, respectively. The certainty equivalent of this system of testing and no RFEM is $1.148/mt.

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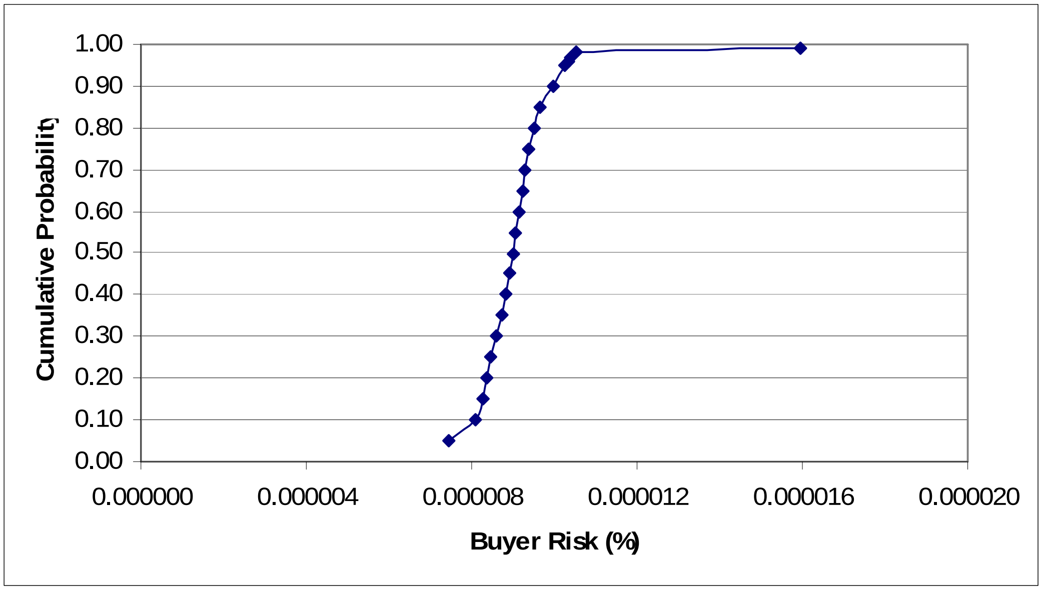
[1] As there are no optional testing locations in this model, it is simply simulated with 5,000 iterations to develop distributions for outcomes.

Table 2. Export Wheat Model Results: Base Case, Testing with RFEM, OSF/OSB

Variables	Base Case	Testing with RFEM	OSF/OSB
Utility	1.2002	1.2002	1.1998
Test (1= yes/0= No) and Intensity % Sampled			
On Farm Storage	0-NA	0-NA	1-100%
Country Elevator Receiving	0-NA	0-NA	1-100%
Country Elevator Load Out	0-NA	0-NA	1-100%
Export Elevator NSig Rail	0-NA	0-NA	1-100%
Export Elevator NSig Barge	0-NA	0-NA	1-100%
Export Elevator NSig Truck	0-NA	0-NA	1-100%
Export Elevator Load Out	0-NA	0-NA	1-100%
Imp. NSig Rec	1-100%	1-100%	1-100%
Export Elevator Sig Rail	NA	1-100%	NA
Export Elevator Sig Barge	NA	1-100%	NA
Export Elevator Sig Truck	NA	1-100%	NA
Imp. Sig Rec	NA	1-100%	NA
Buyer Risk of Flow Cont.	4.8E-7	0.00001	0.0000000048
Seller Risk of Flow Rejected	1.4E-5	0.00019	0.00000017
Total Vol. Diverted	0.0044	8.4563	20.1359
Costs ($/MT)			
Cost of Testing	1.1484	1.1485	2.788494
Cost of RFEM	0	0.0055	0
Cost of Quality Loss	0.00002	0.0446	0.1349
Certainty Equivalent ($/MT)	1.1484	1.1986	2.9282
Comparison to Base		0.0502	1.7798

In the RFEM system, RFEM units are applied on all rail, barge, and truck transportation of bulk wheat from country elevator to the export elevators and on ocean vessels from export elevators to importers. Mandatory testing is assumed for all shipments arriving at the importer and for RFEM units signaling tampering. Optional testing can occur at selected locations (on farm, country elevator receiving and load out, elevator receiving and load out) and intensities. The optimal testing strategy for the RFEM system is to not test at any optional locations (table 2). Testing is only conducted when RFEM lots signal tampering and for all lots arriving at the importer. The average buyer and seller risks are 0.00001 and 0.00019 percent, respectively. Figure 3 (upper and lower left panels) presents the distribution of the buyer and seller risks, respectively, with a 95 percent confidence interval between 0.000006 to 0.000010 percent for buyer risks and 0.000180 to 0.000280 percent for seller risks. An interesting trade implication is that use of RFEM increases the volume of flows removed prior to export shipment, which reduces the volume shipped. Since the amount of export flows rejected at the importer is extremely small in relation to the volume shipped, the drop in shipment volumes for RFEM systems overwhelms the lower volume of shipments rejected at the importer and the percentage of shipment volume appears to cause a net increase.



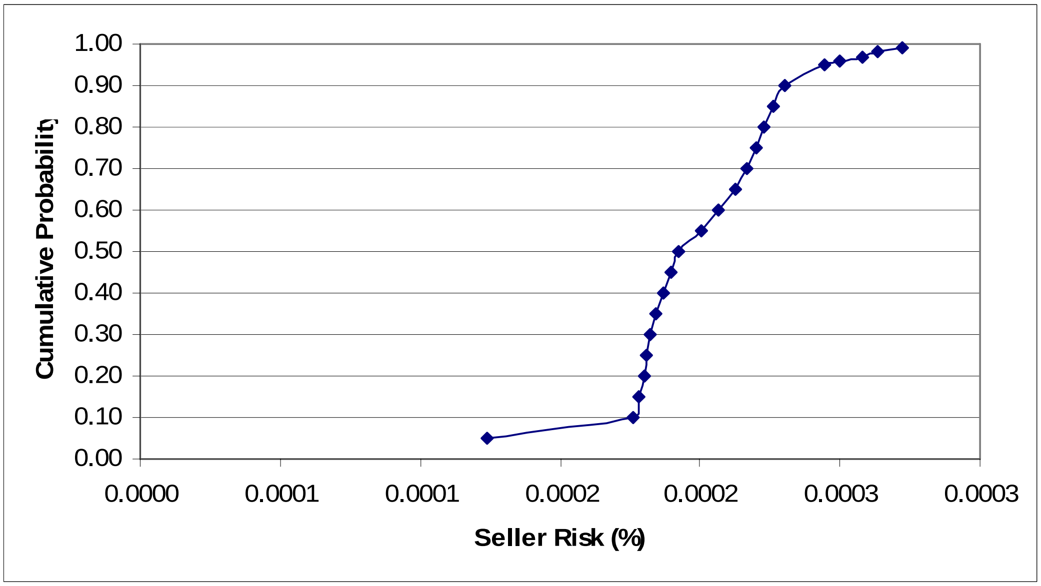
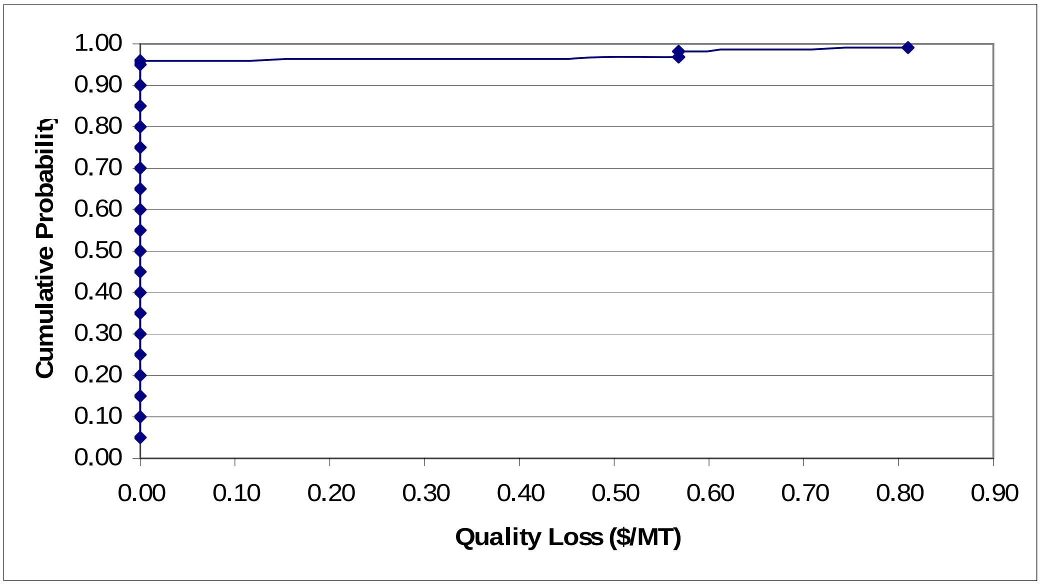


Figure 3. Continued.



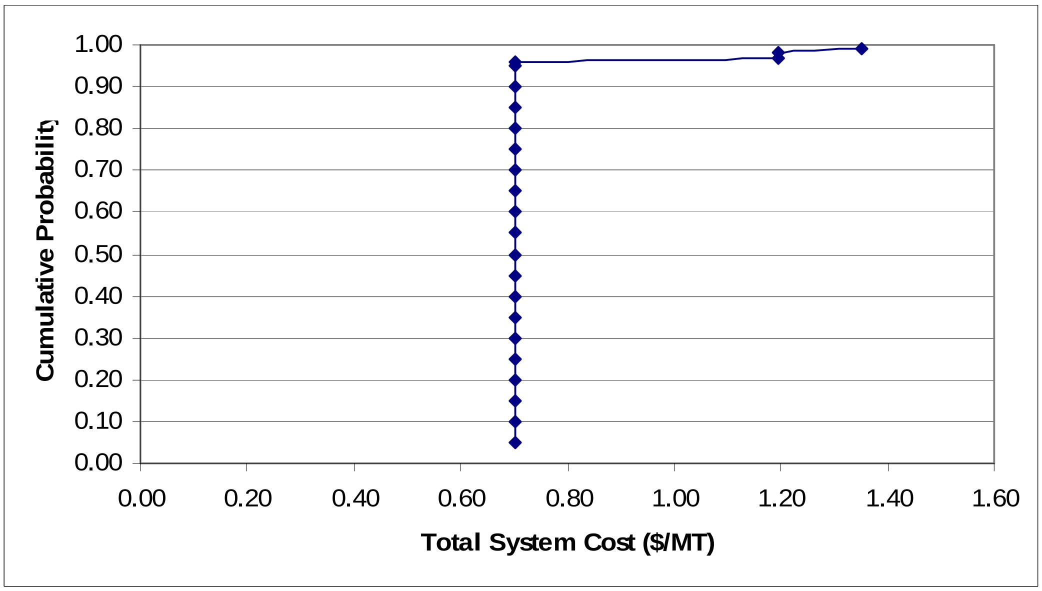


Figure 3. Distributions for Buyer Risk, Seller Risk, Quality Loss Costs, and Total System Costs, Export RFEM Model.

In the RFEM system, the average costs for testing, RFEM tags, and quality loss are $1.149/mt, $0.005/mt, and $0.045/mt, respectively. The distribution of quality loss costs is shown in figure 3 (upper right panel). The results indicate that there is <0.05 percent probability that quality loss costs would be more than nil. Figure 3 (lower right panel) shows the distribution of total costs. The results suggest that there is only a 5 percent probability that the total system or aggregate cost is greater than $0.65/mt. Finally, the certainty equivalent for the RFEM system is $1.198/mt.

In the OSF/OSB system, there is no RFEM system and testing is conducted at all locations for every lot. The buyer and seller risks of this system are 0.0000000048 and

0.00000017, respectively. Costs of testing and quality loss average $2.79/mt and $0.14/mt, respectively. The certainty equivalent for the OSF/OSB system is $2.93/mt. An important trade implication from this result is that overall buyer and seller risks are lower for the OSF/OSB system, indicating better trade flow. However, there may still be significantly higher risks of intentional contamination by terrorist with the OSF/OSB system (as market participants require higher risk premiums) compared to the RFEM system. Also, it is more costly to implement the OSF/OSB system compared to the RFEM system. We therefore conclude that the RFEM system provides real time tracking at lower cost. In the next section, we conduct sensitivities to evaluate the robustness of the RFEM results.

Sensitivities on Key Parameters

Sensitivities are conducted on selected model parameters in the domestic and export models utilizing RFEM to determine the impacts of these parameters on optimal tracking, costs, and risks. Parameters examined include the probability of contamination, cost and reliability of RFEM, and quality loss costs. Results for buyer and seller risks and certainty equivalents of these sensitivities are listed in tables 3 and 4.

Table 3. Export Model: Sensitivity to Alternative Probability of Contamination, Cost of RFEM, Reliability of RFEM, and Cost of Diversion (Testing RFEM)

Variables	Buyer risk	Seller risk	Certainty Equivalent ($/mt)
Prob. of Contamination			
Pr 0.0001	0.00000	0.00000	1.1484
Pr 0.001	0.000006	0.000002	1.1589
Pr 0.01[1]	0.00001	0.00019	1.1986
Pr 0.1	0.00011	0.00229	1.7092
Cost of RFEM			
$0.45/unit[2]	0.00001	0.00019	1.1986
$0.225/unit	0.00001	0.00019	1.1962
$0.675/unit	0.00001	0.00019	1.2016
Reliability of RFEM			
0.90,0.99	0.00001	0.000019	1.1989
0.95,0.99[1]	0.00001	0.00019	1.1999
0.975,0.99	0.00001	0.00020	1.1999
Cost of Diversion			
.25-.10[2]	0.00001	0.00019	1.1986
.50-.30	0.00001	0.00019	1.2034
.75-.50	0.00001	0.00019	1.2079

[1] Pr represents the probability of contamination. Pr 0.01 is the base case model probability of contamination, both for export and domestic wheat flow.

[2] 0.45 cents is the cost of RFEM per unit. This cost is used in the base case cost, both for export and domestic wheat flow.

Table 4. Domestic Model: Sensitivity to Alternative Probability of Contamination, Cost of RFEM, Reliability of RFEM, and Cost of Diversion (Testing RFEM)

Variables	Buyer risk	Seller risk	Certainty Equivalent ($/mt)
Prob. of Contamination			
Pr 0.0001	0.00000	0.00000	0.22554
Pr 0.001	0.0000007	0.0001023	0.24315
Pr 0.01	0.000006	0.0010147	0.400079
Pr 0.1	0.000094	0.008831	1.743791
Cost of RFEM			
$0.45/unit	0.000006	0.0010147	0.400079
$0.225/unit	0.000006	0.0010147	0.398083
$0.675/unit	0.000006	0.0010147	0.402075
Reliability of RFEM	0.000006	0.0010149	0.400105
0.90,0.99	0.000006	0.0010147	0.400079
0.95,0.99	0.00001	0.0010131	0.399782
0.975,0.99			
Cost of Diversion			
.25-.10	0.000006	0.0010147	0.400079
.50-.30	0.000006	0.0010147	0.417578
.75-.50	0.000006	0.0010147	0.435089

Alternative probabilities of intentional contamination ranging from 0.0001 to 0.1 are examined to determine their effect on optimal strategies, buyer/seller risks, and the certainty equivalent. Over this range of probabilities for contamination, the optimal testing strategy did not change. Results (table 3 export and table 4 domestic) show that as the probability of contamination in the supply chain increases, buyer and seller risks and certainty equivalents increase. For the export model, increasing the probability of contamination from the base RFEM model (0.01) to 0.1 increases the certainty equivalent from $1.199/mt to $1.709/mt. For the domestic RFEM model, increasing the probability of contamination from 0.01 to 0.1 increases the certainty equivalent from $0.400/mt to $1.744/mt.

Doubling or halving the cost of RFEM and changes in the reliability of RFEM does not significantly affect the optimal testing strategies and has limited impact on buyer/seller risks and certainty equivalents for both the domestic and export models with RFEM. Changes in the diversion costs for quality loss similarly does not impact optimal testing strategies or buyer and seller risks; however, certainty equivalents increase from $0.400/mt in the base RFEM domestic model to $0.432/mt with aggregate diversion costs distributed between $18.40/mt to $27.60/mt. Effects of diversion costs are less in the export model with RFEM.

[1] 0.95, 0.99 are the reliability of RFEM signaling using a uniform distribution in the base case model in the export and domestic wheat flows.

[2] Base case model for the export and domestic flow used costs of diversion .25 cents buy back and .10 cents for clearing.

SUMMARY AND DISCUSSIONS

The increase in risks associated with bioterrorism has important implications for many industries, but particularly the food system. The reason for this is that the food system is one of the more vulnerable sectors, with large shipment volumes used by several other sectors (World Health Organization, 2002). Also, the United States is both a large consumer and exporter of food; large volumes are shipped in bulk through a number of nodes, each of which has been relatively unprotected. Hence, there are numerous places where contamination could be introduced. For the grain handling industry there are several implications, all of which involve what technology or policy to adopt, if any, as well as costs and risks. Increasingly, food companies will impose these risk mitigation mechanisms onto their supply-chain partners, which suggests that grain companies would be performing a part of these functions.

There are a number of recently developed technologies that can be adopted. These include simply testing periodically; adoption of RFEM; and adapting testing and protocols for OSF/OSB Regulation. In December 2004, the Food and Drug Administration (FDA) issued a Final Food Bioterrorism Regulation for establishment and maintenance of records to track commodity flows OSF/OSB. This legislation is anticipated to increase security and solidify processes to control food terrorism risks. For international food companies, the costs and risk reduction effectiveness resulting from this Regulation may have significant trade implications and are not well understood. Advancements in RFID and RFEM has enormous potential for tracking and data management, and these technologies are already in widespread use by several industries, including inventory management by Wal-Mart. The RFEM mechanism can be used to detect if some form of change in environmental variables has occurred in a shipment. Typically, these devices would be sensors placed on railcar hatches or seals, on barges and bulk ships, and possibly used in on-farm storage.

We use stochastic optimization models to analyze firm-level costs and risk premiums for a vertically integrated firm in the wheat supply chain to be indifferent among alternative tracking strategies. Three strategies were compared: random testing (the base technology), tracking with OSF/OSB Regulation, and tracking with RFEM systems. Models were constructed representing domestic and export supply under uncertainty. The results for the domestic tracking indicate that generally the base case and OSF/OSB systems have similar buyer and seller risks. When comparing costs (testing, RFEM, quality loss) and risk premiums, the base case has the lowest costs, the RFEM the next lowest costs/risk premium, and the OSF/OSB has the highest costs/risk premiums. The vertically integrated firm would require a risk premium of \$1.64/mt to be indifferent between the OSF/OSB system and the base case and \$1.46/mt to be indifferent between the OSF/OSB system and the RFEM system.

In the export models, buyer and seller risks are smallest for the OSF/OSB system, higher for the base case and, while still minimal, highest for the RFEM system. The testing costs are similar between the base case and RFEM system, but in the OSF/OSB system, testing costs are more than twice as high. Similarly, quality loss costs are negligible in the base case, \$0.045/mt in the RFEM system, and increased to \$0.135/mt in the OSF/OSB system. Certainty equivalents for each of the systems display the same pattern as costs. For the base case, the certainty equivalent is \$1.148/mt. For the RFEM system, the certainty equivalent is \$1.199/mt, and in the OSF/OSB system it is \$2.93/mt. Thus, a decision maker would require an additional \$0.051/mt to be indifferent between the RFEM system and the base case and \$1.80/mt to be indifferent between the OSF/OSB system and the base case.

The models developed also provide a systems approach to quantify the value of risk reduction of evolving technology like RFID and RFEM by allowing several sources of uncertainty to be modeled. From an economic perspective, the unit costs of RFID and RFEM technology are meaningless without evaluating their application for specific system usage, since these technologies are evolving. In the case of the grain logistic system, private sector incentives to invest in tracking technology to mitigate food terrorism risk, like RFEM, may alleviate potential trade barrier concerns from the Regulation because these can be used as free market instruments, required by end-users. The potential benefits of eliminating data storage and management costs for tracking with the OSF/OSB are important and should be considered. Including these costs in the analysis will make the OSF/OSB system even more expensive to implement, especially for international food companies. While participants along the grain supply chain may enjoy lower buyer and seller risks with the OSF/OSB system (as a result of increased traceability), the RFEM system may provide better and more cost-effective protection against food terrorism as a result of real time tracking and lower testing costs. Expanding efforts to incorporate real time tracking and private sector monitoring should be highly encouraged.

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IMPORT DEMAND FOR DAIRY PRODUCTS IN CÔTE D'IVOIRE

Joseph V. Balagtas[1], Jeanne Coulibaly[1], James S. Eales[1] and Ibrahim Diarra[2] *

[1] Department of Agricultural Economics, Purdue University, West Lafayette, IN USA
[2] Centre Ivoirien de Recherches Economiques et Sociales (CIRES), Abidjan, Ivory Coast

ABSTRACT

We estimate an LA/AIDS model of demand for imported dairy products for Côte d'Ivoire and use the model to evaluate the welfare consequences of multilateral reform of trade and domestic dairy policy. We employ a unique set of Ivorian customs data, spanning seven dairy products observed monthly from January 1996 to December 2005. Demand for imported milk powder is found to be inelastic, as substitutes for milk powder in the domestic processing industry are scarce. Demand for imported fluid milk, yogurt, and cream are found to be elastic, as products produced domestically from imported powder may substitute for the imports. With the exception of condensed milk, dairy products are found to be necessities. Because of Côte d'Ivoire's heavy reliance on imported dairy product, multilateral policy reform that raises world prices would cause significant welfare consequences. We find that such reform would result in 33 percent reduction in economic welfare for users of imported dairy products.

IMPORT DEMAND FOR DAIRY PRODUCTS IN COTE D'IVOIRE

Population growth, income growth, and increasing urbanization are boosting the demand for food of animal origin, especially dairy products, in developing countries. According to the FAO Food Balance Sheet, per capita cereal consumption in developing countries declined from 164 to 158 kg/year between 1982 and 2002, while milk consumption increased from 25.8 to 45.6 liters/year for the same period (FAO 2004). In Côte d'Ivoire, dairy product sales were an estimated 11.9 billion F.CFA in 1998 (Ekberg 2001) (approximately US$ 22.8 million at the average 2006 exchange rate of 512 F.CFA/US$).

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* Joseph V. Balagtas (corresponding author) is an Assistant Professor, Jeanne Coulibaly is a Graduate Student, and James S. Eales is a Professor, Department of Agricultural Economics, Purdue University. Ibrahim Diarra is Economist, Centre Ivoirien de Recherches Economiques et Sociales (CIRES). This research was supported by the Purdue University Agricultural Experiment Station. The authors thank the editor and two anonymous reviewers for many constructive comments. Balagtas, Coulibaly, and Eales share senior authorship.

Like many developing countries, Côte d'Ivoire relies almost entirely on imports to satisfy demand for dairy products. In 2003 Côte d'Ivoire imported approximately 200,000 mt of dairy products, compared to approximately 25,000 mt produced domestically (MIPARH/DPE 2004). Indeed, dairy products represent the third-most imported food commodity after rice and fish (Gbongue 2002). Contributing to the heavy reliance on imports is an undeveloped domestic dairy sector as well as a relatively low price of milk powder in the international market. Trade policies in developed countries affect the world prices facing Côte d'Ivoire, a small player in the world market. Export subsidies, import barriers, and domestic policies in countries including those in the European Union, the United States, Japan, Korea, and Canada distort trade flows and lower the world prices of dairy commodities (for example, FAPRI 2002, and OECD 2004).

Dairy trade liberalization and domestic policy reform continue to be topics of on-going negotiations in the Doha round of the World Trade Organization. A number of recent studies of dairy trade liberalization scenarios find that world dairy prices would rise significantly as a result of liberalized trade and domestic policy reform (Lariviere and Meilke 1999, Langley et al 2006, FAPRI 2002, OECD 2004, Zhu et al 1999). Thus, it is not surprising that exporting countries such as Australia and New Zealand are pushing hard for trade policy reform. In addition to making some exporters better off, however, liberalized dairy trade would also end the days of low-priced, subsidized exports in countries such as Côte d'Ivoire. Thus, trade liberalization may offer some opportunities for increased prices and incomes for local dairy farmers. On the other hand, given the importance of imports in Ivorian dairy consumption, to the extent that prices rise, dairy trade liberalization and domestic policy reform may also harm consumers in this and other poor nations that rely on dairy imports.

Little economic research exists on the markets for dairy in Côte d'Ivoire or in other West African countries. Exceptions include reports by Nwoko (1986) and by von Massow (1985). Because of the dearth of research, policy makers and economists are unable to analyze and quantify the potential consequences of dairy trade reform on African markets. Such analysis is necessary for considering the full welfare implications of potential WTO scenarios and would also be useful to African governments for planning purposes and to dairy exporters, as well. In this paper, Ivorian demands for imported dairy products are estimated and used to evaluate the performance of the Ivorian dairy market. We also use the estimated import demands to evaluate the welfare consequences of multilateral trade liberalization that raises world dairy prices.

Specifically, we estimate Ivorian demands for imports of seven dairy products—yogurt, milk powder, butter, cream, milk, cheese, condensed milk, and fluid milk—using Ivorian customs data observed monthly from 1996 to 2005. We adopt the Linear Approximate Almost Ideal Demand System (LA/AIDS) model (Deaton and Muellbauer 1980) with imports aggregated over import sources and expenditure assumed to be exogenous. To correct for serially correlated errors, we impose a common AR(1) error structure on all equations. We then use the estimated import demand structure to quantify the effects of multilateral trade liberalization and domestic dairy policy reform on the economic surplus of Ivorian users of dairy imports.

BACKGROUND INFORMATION ON IVORIAN DAIRY INDUSTRY

Ivorian Dairy Production and Marketing

The Ivorian Ministry of Animal Production and Fisheries Resources (MIPARH/DPP 2004) estimates that domestic milk production accounts for 11 percent of total milk consumption in Côte d'Ivoire. Domestic production has been estimated to grow from approximately 17,800 mt in 1990 to 25,000 mt in 2005. Approximately 80 percent of the total production is supplied by the traditional sector, which is comprised of smallholder operations focused mainly on consumption at home. The remaining 20 percent—approximately two percent of total consumption—is supplied by the commercial sector (MIPARH/DPP 2004). While a lack of data prevents an empirical analysis of domestic production, we provide a qualitative description of the sector.

Milk production in the traditional sector takes place mostly in the rural, northern part of the country under pastoral and agro pastoral systems. Average herd size in this region was 15 cows in 2002 (MIPARH/DPP 2002). In this region, cotton, cashew nuts, and mangoes represent the most important sources of revenue for farmers. Livestock is commonly used as draught power and organic fertilizer for the crop enterprise. Milk is considered a livestock by-product and mostly consumed within the farm household (BDPA 2002). This traditional system relies mainly on local breeds with very low milk output. Typical milk production per cow is approximately one to two liters per day during eight months of lactation. The cows are dry the rest of the year.

Under the traditional system, surplus milk (i.e., milk not consumed at home) is marketed as fresh or fermented to consumers in nearby village markets. Marketing is either done directly by farmers or by traders. In either case, milk is delivered on foot or on bicycle. A lack of storage possibility and transportation technology limits the geographical size of the market for fresh milk to nearby consumers.

Prospects for greater and more market-oriented production from the traditional system are constrained by production and marketing challenges. Production challenges include poor genetics (low output per cow), animal disease, and insecure access to pasture. Marketing challenges include long distances to markets, poor transportation infrastructure, and a lack of proper milk sanitation practices. Access to financial capital is also a problem for farmers who might otherwise invest in increase capacity for milk production and marketing.

In contrast, an intensive, modern milk production system exists near the population centers of the urban south. The modern dairy sector uses dairy cows bred specifically for milk production, with milk production per cow in the range of 15 to 20 liters per day (Coulibaly 2004). The modern dairy farms are either private or small cooperative enterprises, but have received financial support from the Ivorian government, foreign governments, and international development organizations such as the African Development Bank.

Both private and cooperative commercial farms are integrated with small-scale, proprietary processing plants that pasteurize the milk and package fresh milk, sour milk, and yogurt. The processed dairy products are then distributed to consumers through small retail outlets.

Dairy Imports

The Ivorian dairy market is dominated by the imports of finished dairy products and of milk powder which is subsequently reprocessed in Côte d'Ivoire. Eighty-nine percent of dairy consumption is supplied by imports (MIPARH/DPP 2004), a figure that has changed little in over the last 20 years. Dairy processing in Côte d'Ivoire is dominated by large manufacturing plants that use imported milk powder as the main dairy ingredient almost exclusively due to the inadequate quantity and uncertain availability and quality of local milk. These large plants manufacture yogurt, cheese, condensed milk, and other dairy products, which are distributed to small retail outlets as well as large supermarkets. Manufacturers also import finished dairy products to supply directly to large supermarkets. Dairy products are also imported directly by supermarkets, or by importers who sell to supermarkets. In addition to being much more abundant than products made from domestic milk, imported dairy products are also of higher quality. Thus, the markets for imports and domestic products do not overlap.

The main supplier of dairy imports is the European Union, and particularly France, which maintains strong historical, cultural, and economic links (table 1). E.U. countries supply almost 80 percent of Ivorian dairy consumption. France supplies the majority of finished dairy products, while a number of countries serve the milk powder market.

Like many other countries in West Africa, Côte d'Ivoire's dairy development policy initially was driven by food security. This policy called for dairy imports to supplement inadequate domestic supplies. Starting from independence in the 1960s, dairy imports entered the country with nominal tariffs and nonrestrictive quotas. Cheap dairy imports further discouraged domestic production.

In 1990, the government changed course and took some measures to regulate imports in order to promote domestic milk production and to increase tariff revenue. These policies were pursued through instruments such as import licenses and higher import tariffs. Moreover, during the years 1990-1991, the government required that importers purchase 40 percent of their products from SIALIM (Ivorian Society for Food), a government-run enterprise that processed imported powder milk into final products such as condensed milk, yogurt, etc. This requirement no longer exists and SIALIM is out of business.

Despite the economic barriers implemented by the government in order to limit dairy imports and develop the domestic industry, dairy imports continued to grow and local production remained negligible. In 1993, the Ivorian government set up some emergency measures to develop and modernize the local dairy industry and to reduce imports. These measures consisted mostly of programs aimed at improving the genetics of the national herd. The development efforts targeted the commercial sector, where low disease pressure, greater feed availability, and more reliable market outlets were more amenable to the improved breeds. However, efforts to improve the performance of the national dairy herd have shown little success so far, in part because of technical and financial mismanagement.

Table 1. Average Dairy Import Expenditure Shares by Source Country, 1/1996-12/2005

Products and Source Country	Share of Total Expenditure on Imported Dairy Products[a]	Source-country Share of Product Expenditure[a]
Milk powder	0.532	
United Kingdom		0.346
Ireland		0.177
France		0.157
Netherlands		0.144
Other countries		0.176
Condensed milk	0.339	
Netherlands		0.551
Germany		0.142
France		0.099
Malaysia		0.053
Other countries		0.156
Cheese	0.053	
France		0.720
Morocco		0.172
Other countries		0.108
Fluid milk	0.028	
France		0.935
Other countries		0.065
Butter	0.021	
France		0.657
Belgium		0.206
Other countries		0.137
Yoghurt	0.015	
France		0.941
Other countries		0.059
Cream	0.012	
France		0.909
Other countries		0.091

Source: Authors' calculations using data from Ivorian Customs Service, Department of Statistics. Countries with less than 5 percent expenditure share for any product were grouped into "Other countries."

[a] For example, expenditure on milk powder accounted for 53.2 percent of total dairy expenditure over the sample period; milk powder imports from the United Kingdom accounted for 34.6 percent of total expenditure on milk powder imports.

Import tariffs remain an important component of the dairy development programs, as well as a source of government revenue. Tariff rates that applied during 2001-2006 for various dairy products are reported in table 2. These tariff rates applied to imports from all sources, including E.U. countries. Notably, the effect of the specific pattern of tariffs—high tariffs on finished products, lower tariffs on milk powder—is to promote domestic manufacturing of finished dairy products from imported powder.

Table 2. Ivorian Import Duties for Dairy Products, 2001-2006

	Import tariff	V.A.T.	Other[a]	Cumulative total
	percent			
Dry milk powder	5.0	20.0	2.2	27.2
Condensed milk	20.0	20.0	5.2	45.2
Cheese	20.0	20.0	5.2	45.2
Fluid milk	20.0	20.0	5.2	45.2
Butter	20.0	20.0	5.2	45.2
Yogurt	20.0	20.0	5.2	45.2
Cream	5.0	0.0	1.0	6.0

Source: Service des Douanes Ivoirien/Departement des Statistiques

[a] "Other" includes fees for the Ivorian Customs Service, a common tax for the Economic Community of West Africa (ECOWAS), and a social security tax.

MODELING FRAMEWORK

Given the near-total reliance of Côte d'Ivoire on dairy imports, we develop a model of Ivorian dairy imports in order to evaluate potential economic implications of multilateral dairy trade and policy reform that may influence world dairy prices. Côte d'Ivoire imports finished dairy products as well as an intermediate good, milk powder, which is manufactured domestically into finished products. Conceptually, imported and locally manufactured finished dairy products compete for a share of Ivorian consumers' dairy budget, although the imported products are differentiated by quality. The changes in relative prices of imported finished products resulting from changes in world prices or changes in tariff rates cause shifts demands for domestically manufactured finished products. The resulting change in profitability of local manufacturers shifts the derived demand for imported milk powder. Conversely, changes in the landed price of milk powder affects the price of finished products manufactured from milk powder, and thus shifts demand for imported finished products. Thus, relative price changes affect the composition as well as the aggregate quantity of dairy imports.

In our econometric analysis of Ivorian demand for dairy imports, we adopt the linear approximate almost ideal demand system (LA/AIDS) proposed by Deaton and Muellbauer (1980), one of the most widely used models for empirical demand studies due to its flexible functional form (e.g., Yang and Koo 1994; Eales and Unnevehr 1988; Green and Alston 1990; Fulponi 1989; Hayes et al. 1990). The LA/AIDS provides an arbitrary first order approximation to any demand system, satisfies the axiom of choice, and under certain conditions, aggregates perfectly over consumers (Deaton and Muellbauer 1980). The LA/AIDS model takes the following form:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log(p_j) + \beta_i \ln(X/P)$$

where w_i denotes the budget share of commodity i, p_j is the price of commodity j, X is the total expenditure on all n commodities, P is Stone's price index, defined as

(1) $\ln(P) = \sum_{i=1}^{n} w_i \ln(P_i/\overline{P_i})$,

and the α_i, γ_{ij}, and β_i are parameters to be estimated.

Restrictions imposed by demand theory are expressed in terms of restrictions on the model's parameters:

(2) $\sum_{i=1}^{n} \alpha_i = 1$; $\sum_{i=1}^{n} \gamma_{ij} = 0$; $\sum_{i=1}^{n} \beta_i = 0$ (adding up)

(3) $\sum_{j=1}^{n} \gamma_{ij} = 0$ (homogeneity)

(4) $\gamma_{ij} = \gamma_{ji}$ (symmetry).

Marshallian (uncompensated) elasticity of demand is computed from the estimated parameters of the model. These elasticities are estimated as follows (see, for example, Green and Alston 1990; Hayes et al. 1990):

(5) $\eta_{ij} = -\delta_{ij} + \gamma_{ij} / w_i - \beta_i w_j / w_i$

where δ_{ij} is the Kronecker delta, $\delta_{ij} = 1$for $i = j$ and zero otherwise.

Expenditure elasticity of demand for each product is expressed as

(6) $\varphi_i = \beta_i / w_i + 1$.

DATA AND ESTIMATION PROCEDURES

Data Description

We use monthly data over the period 1996-2005 to estimate the model. The data are from the Statistics Department of the Ivorian Customs Service (Service des Douanes Ivoirien/Department des Statistiques), and comprise import values and quantities for seven aggregate dairy commodities: milk powder, fluid milk, yogurt, butter, cheese, condensed milk and cream. These products include the vast majority of dairy products imported and consumed over the observed period. Summary statistics are reported in table 3.

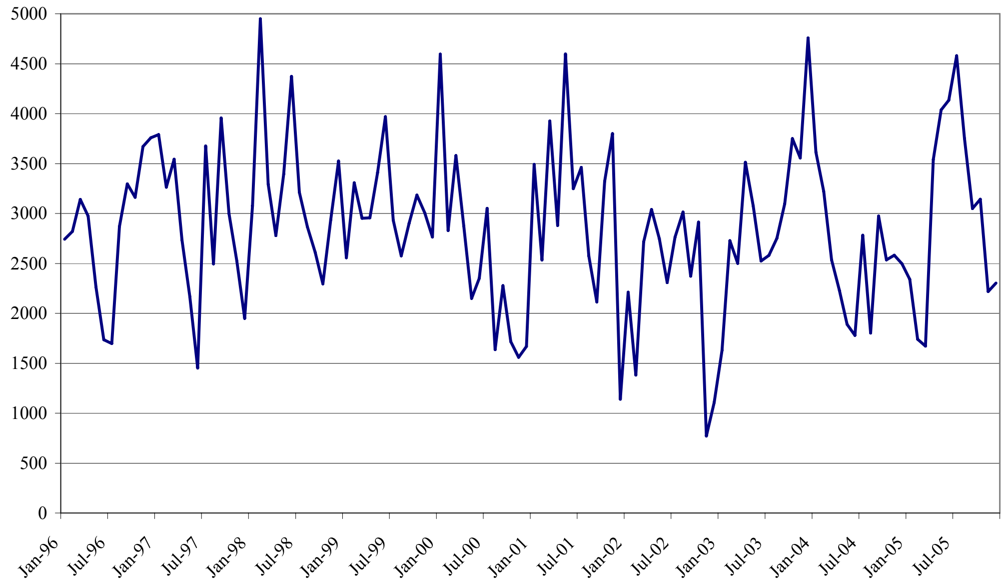
Table 3. Summary Statistics for Ivorian Dairy Imports, 1/1996-12/2005 (monthly)

NAME	Mean	Standard deviation	Minimum	Maximum
Quantities (1000 kg)				
Milk powder	1,037	385	266	2,151
Condensed milk	1,077	554	149	3,151
Cheese	39	17	2	81
Fluid milk	148	111	7	490
Butter	31	20	0	90
Yogurt	13	9	3	66
Cream	54	73	0	365
Prices (F.CFA/kg)				
Milk powder	1,483	213	921	2,115
Condensed milk	924	177	543	1,435
Cheese	3,665	564	2,345	6,919
Fluid milk	603	208	96	1,716
Butter	1,906	460	847	3,980
Yogurt	3,366	949	962	6,246
Cream	1,739	2,186	328	12,838
Total expenditure (Mil. F.CFA)	2,857	803	772	4,953
Expenditure shares				
Milk powder	0.532	0.131	0.230	0.802
Condensed milk	0.339	0.140	0.052	0.713
Cheese	0.053	0.026	0.006	0.153
Fluid milk	0.028	0.017	0.003	0.077
Butter	0.021	0.016	0.000	0.095
Yogurt	0.015	0.007	0.003	0.050
Cream	0.012	0.015	0.000	0.069

Source: Service des Douanes Ivoirien/Departement des Statistiques.

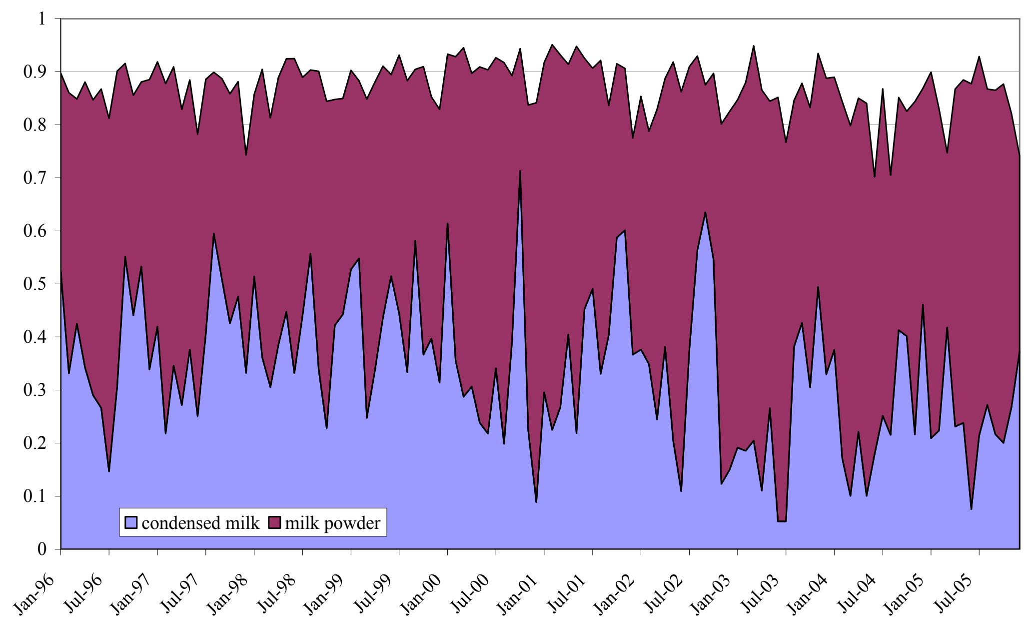
Figure 1a plots total expenditure for imported dairy products over time. Import values reflect prices at the Ivorian port of Abidjan, including all relevant tariffs and fees (see table 2). Total expenditure on dairy imports was variable over the sample period, but did not display an obvious time trend. Figure 1b plots the expenditure shares for milk powder and condensed milk. These two products together accounted for, on average, 87 percent of total expenditure on dairy imports over the sample period (table 3). As was discussed above, most of the imported milk powder is manufactured into final dairy products such as reconstituted milk and yogurt.

As discussed above, the majority of domestic milk production is not market-oriented. The commercial dairy sector that is market-oriented is tiny—accounting for approximately two percent of total milk consumption. Moreover, products manufactured from local milk are of poor and variable quality and are perceived as poor substitutes for imported products and products manufactured locally from imported milk powder. Thus we assume separability between domestic and imported dairy. We discuss the implications of this assumption and directions for further work in the conclusion of the paper.



Source: Ivorian Customs Service, Department of Statistics.

Figure 1A. Ivorian Dairy Import Expenditure, 1/1996-10/2005 (Mil. F.CFA).



Source: Ivorian Customs Service, Department of Statistics.

Figure 1B. Dairy Import Expenditure, Shares for Milk Powder and Condensed Milk.

Estimation Procedures

We estimate the LA/AIDS model (equation 0) by Zellner's Seemingly Unrelated Regressions (1962). Because of the adding up condition, the covariance matrix is singular, and therefore one equation was deleted from the system. Barten (1969) has shown that when the disturbances are serially uncorrelated, the parameters estimate are the same regardless of which equation is omitted. Thus, we estimate the model with six share equations (milk powder, condensed milk, fluid milk, cheese, yogurt, butter), and impute the coefficients for the share equation for cream from the estimated coefficients of the other six share equations, together with homogeneity and symmetry restrictions. To avoid the problem of endogeneity, we use lagged shares in the calculation of Stone's price index (Eales and Unnevehr 1988).

To account for potential seasonality, we allow for monthly dummy variables in each share equation. On the basis of a likelihood ratio test, we are able to reject at the 5 percent level the null hypothesis that the monthly dummies are jointly equal to zero. Thus we include the monthly dummies. We impose homogeneity and symmetry on the model. Durbin-Watson statistics indicate serially correlated errors when the model is estimated by SUR. Thus, we also estimate a model with a single, first-order autoregressive structure imposed on the errors.

ECONOMETRIC RESULTS

Results from the model estimated by SUR without correction for serially correlated errors are reported in table 4. Results from the model estimated with an AR(1) error structure imposed are reported in table 5. The estimated autoregressive coefficient is 0.207, with a standard error of 0.046. The AR(1) error structure improves the R^2 for each equation. Estimated coefficients are very similar to those estimated by SUR without correcting for serially correlated errors, thus we calculate demand elasticities only for the model with AR(1) errors.

Substituting the estimates from table 5 into equations (5) and (6) we calculate point estimates of the elasticities of demand with respect to prices and expenditure, which we evaluate at the means of the data. The resulting elasticities are reported in table 6. Demand for milk powder is price-inelastic, with an own-price elasticity of demand of -0.535. An inelastic derived demand for imported milk powder is consistent with the fact that the local Ivorian milk supply is of inadequate quantity and quality to substitute for milk powder in the manufacture of dairy products.

Moreover, an increase in the price of milk powder results in an increase in demand for all other products, with the exception of condensed milk. These findings are consistent with substitution in final consumption between dairy products manufactured locally from imported powder, and imported dairy products.

Demand for imported fluid milk, yogurt, and cream is elastic. Again, this finding reflects the availability of substitute products manufactured locally from imported milk powder. In contrast, the demand for condensed milk is price inelastic, with an estimated own-price elasticity of -0.133. Further, condensed milk stands out from the other products in that it complements other dairy products.

Table 4. Regression Results for the LA/AIDS Model for Ivorian Demand for Dairy Imports, Without Correction for AR Error

		Price Coefficients									
	Constant	Milk powder	Condensed milk	Cheese	Fluid milk	Butter	Yogurt	Cream	Total Expenditure	R^2	DW
Expenditure share for:											
Milk powder	1.153* (0.648)	0.242*** (0.053)	-0.259*** (0.046)	0.013 (0.012)	-0.004 (0.009)	0.002 (0.009)	-0.003** (0.003)	0.010** (0.005)	-0.037 (0.030)	0.36	1.41
Condensed milk	-1.916*** (0.629)	-0.259*** (0.046)	0.332*** (0.046)	-0.038*** (0.009)	-0.007 (0.006)	-0.014** (0.007)	-0.002** (0.002)	-0.012*** (0.005)	0.113*** (0.029)	0.46	1.47
Cheese	0.752*** (0.125)	0.013 (0.012)	-0.038*** (0.009)	0.008 (0.008)	0.014*** (0.004)	-0.000 (0.005)	0.003 (0.002)	0.001 (0.001)	-0.032*** (0.006)	0.41	1.51
Fluid milk	0.265*** (0.089)	-0.004 (0.009)	-0.007 (0.006)	0.014*** (0.004)	-0.011*** (0.004)	0.003 (0.003)	-0.000 (0.001)	0.005*** (0.001)	-0.012*** (0.004)	0.30	1.80
Butter	0.197** (0.091)	0.002 (0.009)	-0.014** (0.007)	-0.000 (0.005)	0.003 (0.003)	0.006 (0.005)	0.004** (0.002)	0.000 (0.001)	-0.008* (0.004)	0.14	1.93
Yogurt	0.315*** (0.030)	-0.003** 0.003)	-0.002** (0.002)	0.003 (0.002)	-0.000 (0.001)	0.004** (0.002)	-0.002 (0.001)	0.000 (0.000)	-0.014*** (0.001)	0.55	1.52
Cream	0.235*** (0.076)	0.010** (0.005)	-0.012*** (0.005)	0.001 (0.001)	0.005*** (0.001)	0.000 (0.001)	0.000 (0.000)	-0.003*** (0.000)	-0.010*** (0.004)	0.32	1.34

Standard deviations are in parentheses. * indicates statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level. A LR test of the joint significance of monthly dummy variables was rejected at the 5 percent level. Thus, monthly dummy variables were included in each share equation, but the coefficients are suppressed here.

Table 5. Regression Results for the LA/AIDS Model for Ivorian Demand for Dairy Imports, With AR(1) Errors

		Price Coefficients									
	Constant	Milk powder	Condensed milk	Cheese	Fluid milk	Butter	Yogurt	Cream	Total Expenditure	R^2	DW
Expenditure share for:											
Milk powder	1.143* (0.547)	0.232*** (0.069)	-0.266*** (0.060)	0.019 (0.015)	0.001 (0.011)	0.000 (0.013)	-0.000 (0.004)	0.013** (0.006)	-0.030 (0.033)	0.41	1.79
Condensed milk	-1.964*** (0.679)	-0.266*** (0.060)	0.339*** (0.062)	-0.038*** (0.012)	-0.053 (0.009)	-0.013* (0.009)	-0.002 (0.003)	-0.015*** (0.006)	0.106*** (0.032)	0.50	1.87
Cheese	0.794*** (0.136)	0.019 (0.015)	-0.038*** (0.012)	0.006 (0.010)	0.011** (0.005)	-0.001 (0.006)	0.002 (0.002)	0.000 (0.001)	-0.033*** (0.006)	0.44	1.91
Fluid milk	0.295*** (0.101)	0.001 (0.011)	-0.053 (0.009)	0.011** (0.005)	-0.011** (0.005)	0.001 (0.004)	-0.001 (0.002)	0.004*** (0.001)	-0.012** (0.005)	0.35	2.27
Butter	0.168* (0.104)	0.000 (0.013)	-0.013 (0.009)	-0.001 (0.006)	0.001 (0.004)	0.007 (0.007)	0.005*** (0.002)	0.000 (0.001)	-0.007* (0.005)	0.12	2.30
Yogurt	0.315*** (0.034)	-0.000 (0.004)	-0.002 (0.003)	0.002 (0.002)	-0.001 (0.002)	0.005** (0.002)	-0.003** (0.002)	0.000 (0.001)	-0.014*** (0.002)	0.60	1.83
Cream	0.249*** (0.089)	0.013** (0.006)	-0.015*** (0.006)	0.000 (0.001)	0.004*** (0.001)	0.000 (0.001)	0.000 (0.001)	-0.002** (0.001)	-0.010*** (0.004)	0.41	1.81

Standard deviations are in parentheses. * indicates statistical significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level. Monthly dummy variables were included in each share equation, but the coefficients are suppressed here. The estimated autoregressive coefficient is 0.207, with a standard error of 0.046.

Table 6. Marshallian Elasticities of Ivorian Demand for Dairy Imports Using the LA/AIDS Model With AR(1) Errors

	Milk powder	Condensed milk	Cheese	Fluid milk	Butter	Yogurt	Cream	Total Expenditure
Milk powder	-0.535	-0.480	0.039	0.004	0.003	0.000	0.025	0.944
Condensed milk	-0.951	-0.107	-0.128	-0.024	-0.045	-0.011	-0.048	1.313
Cheese	0.696	-0.498	-0.845	0.228	-0.004	0.042	0.015	0.368
Fluid milk	0.272	-0.045	0.419	-1.390	0.056	-0.032	0.140	0.580
Butter	0.201	-0.502	-0.028	0.071	-0.666	0.254	-0.021	0.691
Yogurt	0.468	0.167	0.164	-0.046	0.378	-1.222	0.017	0.074
Cream	1.602	-0.943	0.081	0.344	-0.025	0.021	-1.155	0.074

Source: Authors' calculations based on equations (5) and (6) in the text, together with parameter estimates reported in Table 4. All elasticities are evaluated at the means of the data.

With the exception of condensed milk, expenditure elasticities are all less than one, indicating that these dairy products are necessities. This finding is somewhat surprising for the finished dairy products (cheese, fluid milk, butter, yogurt, cream), since dairy product imports in other countries are often perceived as expensive, high-quality luxuries. This result may reflect the importance of imported dairy protein in Ivorian diets. Condensed milk is found to be a luxury good, as expected.

WELFARE IMPLICATIONS OF MULTILATERAL DAIRY POLICY REFORM

We use the model to evaluate the welfare implications of changes in world dairy prices resulting from dairy policy reform. A number of studies have simulated the economic effects of multilateral dairy trade liberalization and domestic policy reform (Langley et al. 2006, Lariviere and Meilke 1999, FAPRI 2002, OECD 2004, Zhu et al. 1999, among others). Table 7 reports the estimated effects on world prices of selected dairy products as reported by these studies. While methodology, data, and parameters vary across studies, the common finding is that full dairy trade liberalization combined with domestic dairy policy reform would result in higher world prices for dairy products. This result is driven in large part by the elimination of import restrictions and export subsidies around the world.

Table 7. Estimates of Changes in World Dairy Prices Resulting from Dairy Trade Liberalization and Policy Reform

	OECD (2004)	FAPRI (2002)	Lariviere and Meilke (1999)	Zhu et al. (1999)[a]	Langley et al (2006)
	(percentage change)				
Skim milk powder	21.6	30	15	22.1	13
Whole milk powder	16.9	26		33.6	24
Condensed milk				7.8	
Cheese	34.5	22	44	20.3	50
Butter	57.4	40		46.2	66

a. Changes in Prices for Oceania.

We use the model of Ivorian import demand estimated above to quantify the welfare implications of higher world dairy prices resulting from dairy trade liberalization and domestic policy reform. We take the 1996-2005 sample means (table 3) as the initial, pre-liberalization equilibrium prices and quantities in Côte d'Ivoire, at which our estimated demand elasticities (table 6) apply. As a measure of the welfare consequences of trade liberalization, we calculate the change in consumer surplus under the assumption that import demand for each product is linear in own- and cross-prices. Note that this welfare measure captures not only changes in final consumer surplus, but also changes in producer surplus for Ivorian suppliers of marketing and manufacturing inputs. Thus, we interpret this welfare measure as the aggregate effect on economic welfare along the Ivorian supply chain for imported dairy products (including effects on importers, manufacturers, wholesalers, retailers, and consumers).

We choose values for the exogenous changes in world dairy prices that fall in the range of published estimates. In addition to changes in world prices, we assume that Côte d'Ivoire eliminates tariffs on dairy products. Notably, percentage increases in world dairy prices are larger than the Ivorian tariff rates, so that dairy trade liberalization and policy reform causes a net increase in the landed prices of Ivorian imports of dairy products. Changes in world prices, initial tariff rates, and welfare effects are reported in table 8. Dairy trade liberalization and policy reform shrinks Ivorian welfare for five of the seven imported products (milk powder, condensed milk, cheese, butter, and cream), with the largest losses realized in the market for condensed milk as a result of relatively inelastic import demand for this product. For two products (fluid milk and yogurt), dairy trade liberalization and policy reform increases Ivorian welfare. This result stems from the relatively elastic demand for these products, together with net increases in demand for these products caused by cross-price effects.

The net effect of dairy trade liberalization and policy reform on the Ivorian economy is a loss of approximately 2.1 billion F.CFA per month, approximately US$4.0 million at the average 2006 exchange rate of 512 F.CFA/US$. This loss is almost imperceptible relative to the overall economy (monthly average GDP was US$1.4 billion in 2006). However it represents a 33 percent reduction in net Ivorian benefits from dairy imports. Put another way, the Ivorian dairy economy reaps benefits from the status quo polices around the world that tend to depress world dairy prices.

In contrast, Ivorian trade policy for dairy harms domestic users of dairy products. In our simulation of policy reform, the elimination of Ivorian tariffs softens the impact of higher world dairy prices. Indeed, elimination of Ivorian tariffs would generate benefits for Ivorian users of dairy imports regardless of whether multilateral trade liberalization is realized.

Table 8. Implications of Multilateral Dairy Policy and Trade Reform for Economic Welfare in Côte d'Ivoire (monthly)

	Exogenous change in world price	Initial tariff rate	Net change in landed price	Change in Economic Surplus	
	(percent)	(percent)	(percent)	(1000 F. CFA/month)	(percent)
Milk powder	20	5	15	-310,799	-22
Condensed milk	30	20	10	-1,702,287	-37
Cheese	35	20	15	-31,886	-38
Fluid milk	30	20	10	746	2
Butter	55	20	35	-18,065	-41
Yogurt	30	20	10	4,605	26
Cream	30	5	25	-7,932	-20
Total				-2,065,619	-33

Source: authors' calculations, except for initial tariff rates, which are from Service des Douanes Ivoirien/Departement des Statistiques.

Conclusion and Directions for Further Research

Côte d'Ivoire relies heavily on imports to satisfy demand for dairy products, and thus is sensitive to changes in world dairy prices. We estimate Ivorian import demand for seven dairy products and quantitatively evaluate the welfare implications of higher world prices resulting from multilateral dairy trade liberalization and domestic policy reform. Results confirm that multilateral reform of domestic and trade policies affecting world dairy markets would cause substantial welfare losses for Ivorian consumers, dairy manufacturers, and others involved in the import-reliant Ivorian dairy economy.

The absence of a market-oriented domestic dairy sector contributes to the vulnerability of Côte d'Ivoire to world price increases. A viable domestic industry would benefit from higher world prices, thereby reducing the negative welfare effects on the country. It would also reduce the consumer losses caused by higher world prices by providing a substitute for imports (making import demand more elastic). However, given the current reliance on dairy imports, Ivorian trade policy for dairy, which imposes significant tariffs on imports, generates a net loss for the Ivorian economy; Côte d'Ivoire would benefit from unilaterally dismantling its tariffs on dairy. This is not to say that there is no public role for promoting a domestic dairy sector. Policies that may help a domestic sector without harming users of dairy products include continued public efforts to provide technical assistance and to promote international technology transfer to improve productivity and quality (Beghin 2006).

This research may be extended in several directions. Yang and Koo (1994) argued that source differentiation is important for import demand analysis. In the present context, the historical and economic links between Côte d'Ivoire and France might lead to a preference for French dairy products. A source-differentiated import demand model might reveal such preferences, with implications for the effects of bilateral or regional trade.

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THE ROLE OF NON-TRADITIONAL AGRICULTURAL COMMODITY EXPORTS IN ATTAINING EXPORT EARNING STABILITY: THE CASE OF ETHIOPIA

***Moti Jaleta*[*,1] and Cornelis Gardebroek*[2]**

[1] Hawassa University, Awassa College of Agriculture, Dept. of Agricultural Resource Economics and Management, Awassa, Ethiopia

[2] Agricultural Economics and Rural Policy Group, Wageningen University, The Netherlands

ABSTRACT

This paper examines export earnings instability of Ethiopia and the role that non-traditional agricultural export commodities could play in attaining stable foreign currency earnings. A portfolio analysis is performed on nine years of export data to capture the degree of variation in the annual export earnings of Ethiopia and the contribution of each agricultural export commodity to the overall export income variation. Results show that coffee contributes most to the export income instability due to its continuously declining world market price till 2003 and its large share in the total export earnings of the country. On the other hand, export earnings from commodities like hide and skin, cotton, cereals, and pulses have reduced the overall instability. This implies that policy makers in Ethiopia should stimulate production of these crops if they want to attain stable export earnings through export diversification.

Keywords: agriculture, export, portfolio analysis, Ethiopia.

Export growth is a crucial issue for the development of a nation's economy. In addition to export growth, the stability in the export earnings is also an important issue since instability disturbs the development planning of a country (Stanley 1999). Most of the export earning instability appears from world market price fluctuations and external shocks that directly affect the export volume like weather factors and pests and diseases. Both factors have a significant effect on export earning instability. For countries like Ethiopia that mainly depend on a few primary agricultural commodities for their export earnings (traditional products like coffee and hides and skins) and with minimum capacity to establish agricultural processing

[*] Corresponding author: Moti Jaleta, P. O. Box 5, Awassa, Ethiopia. Tel.: +251 (0)911 773219, Fax: +251 (0)462 205421, Email: moti_jaleta@yahoo.com

industries (vertical diversification) that add value to primary goods and produce quality export products, horizontal diversification of the export base seems indispensable to tackle the export income instability problem (Alwang and Siegel 1994; Bigman 2002). In addition, Ethiopia has diverse agro-ecological zones so that different non-traditional agricultural export commodities can be produced with minimum adjustment to existing production systems.

Diversification of the export base does not necessarily result in stable export income (Alwang and Siegel 1994). If commodities in the diversified export portfolio covary in prices and output quantities, then export stability is still not attained. Therefore, focus should be on commodity mixes that could realize the earning stability goal. The objective of this paper is to analyze the variability in the agricultural export mix of Ethiopia in recent years and to identify commodities that lead to export income stability through export diversification and the degree to which they make such contributions. Agricultural export products that contributed much to export earnings variability and commodities that helped to stabilize export income are identified. To meet this objective a portfolio analysis, as developed by Markowitz (1959) and adapted by Love (1979) and Alwang and Siegel (1994) is performed. This paper enriches the existing body of literature discussing the role of non-traditional agricultural export commodities. Moreover, this paper is relevant to policy makers since it sheds light on the importance of these commodities in attaining export income stability.

The paper is structured as follows. In section 2, the overall performance of Ethiopia's export sector is briefly reviewed and special attention is paid to the role of non-traditional agricultural export commodities. Section 3 discusses the research methodology. In section 4 the estimation results are presented. General discussion and conclusions drawn from the analysis are presented in section 5.

THE PERFORMANCE OF ETHIOPIA'S EXPORT SECTOR

Agricultural commodity export is almost the only source of export earnings for Ethiopia (Keyzer, Merbis, and Overbosch 2000; Befekadu, Berhanu, and Getahun 2001). For instance, the share of agriculture in total export value was 97.2% in 1997 although it declined to 82.3% in 2002 and increased back to 89.3% in 2005 (see table 1). The decline in the share of agricultural exports can be explained from both the demand and supply side. From the demand side, there was a tremendous decline in the world market prices for agricultural export commodities, especially coffee, till 2003 and a trade ban on live animals from East Africa by the Middle East Arab countries due to the Rift Valley Fever[1]. Weather, diseases, and other external factors represent supply side factors that explain the cut in the volume of agricultural exports.

Table 1. The Share of Agricultural Commodities in Total Export Income of Ethiopia

	Year								
	1997	1998	1999	2000	2001	2002	2003	2004	2005
Percentage share	97.2	96.1	96.3	89.9	85.6	82.3	92.2	81.5	89.3

[1] Rift Valley Fever is a cattle disease that occurred in the Rift Valley region of Kenya and Tanzania. Following the outbreak of this disease, the Middle East Arab countries put a ban on import of live animals, meat and meat products from East African countries. The ban was lifted later gradually.

In addition to dependency on agricultural commodity exports, on average, about 67.5% of Ethiopia's total export earning is directly coming from only three agricultural commodities: coffee, oilseeds, and hide and skin (see table 2).

Table 2. The Share of Some Agricultural Commodities in the Total Exports, 1997-2005

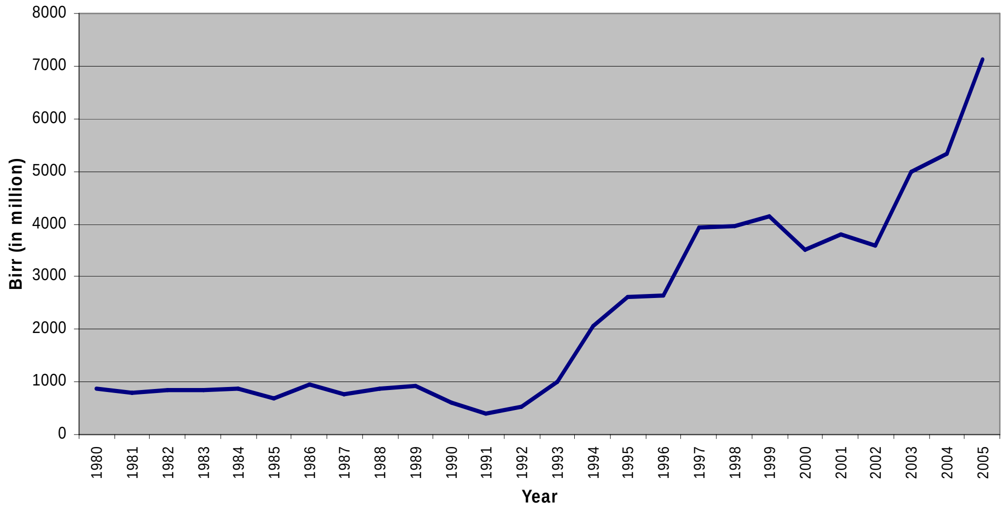
Commodity	Average share (%)	Cumulative (%)
Coffee	47.74	47.74
Oilseeds	10.06	57.80
Hide and skin	9.72	67.52
Pulses	3.62	71.14
Cereals	1.91	73.05
Fruits, vegetables and flowers	1.71	74.76
Cotton	1.46	76.22
Meat	0.87	77.09
Spices	0.85	77.94
Live animals	0.54	78.48
Tea	0.14	78.62
Others	21.36	100.00

Source: Ethiopian Customs Authority 2006.

Moreover, Ethiopia's export is concentrated to Europe and Asian Markets. For instance, in 2000 about 76.1% of Ethiopia's export was traded with few countries in Europe and Asia whereas other African countries and America had only shares of 18.0% and 5.6%, respectively (Berhanu, Kibre, and Worku 2002). A concentrated direction of trade is more susceptible to trade restriction policies imposed by importing countries and this problem is severe when the number of importing countries is few. National or regional trade policies imposed on imported commodities have a detrimental income instability effect on exporting countries with more concentrated direction of trade than with diversified ones. Such a large concentration of export income from only a few primary agricultural commodities and a limited number of trade partners (Berhanu, Kibre and Worku 2002) makes export income vulnerable to price and non-price policy shocks like the sanitary and phytosanitary regulations imposed by EU on import products from developing countries.

Figure 1 illustrates the annual export earnings of Ethiopia for the period of 1980 to 2005[2]. During the centrally planned economic system from 1980 to 1990, export income was almost constant. After a short period of declining export earnings in 1991 and 1992, a transition period after the overthrow of the socialist government, export earnings started to increase following the 1992's monetary devaluation policy and a structural adjustment program. Export earnings increased till 1998, the time when the war between Eritrea and Ethiopia broke out. Starting from the year 1998 till 2002, there is a slightly downward trend in the export earnings with some annual fluctuations in the amount. But, from 2002 onwards there is a positive growth in the total export income of Ethiopia.

[2] Birr is the Ethiopian currency (During this study, 1USD≈8.6Birr or 1EURO≈10Birr).



Source: Ethiopian Custom Authority, 2006.

Figure 1. Ethiopia's annual export earnings.

Looking at commodity specific export performance of Ethiopia, coffee, with the largest share in the total export value, was varying both in terms of quantity and price. From 1997 to 2003, there was a continuous decline in coffee prices though prices increased again in 2004 and 2005. The quantity of coffee export was declining from 1997 to 2001 but there has been an annual increment in the volume of coffee traded from 2001 to 2005.

Being preceded by oilseeds the export of hide and skin lost its historical second largest share in the total export income and became the third. Pulses and cereals rank fourth and fifth, respectively, in the total share. Fruits-vegetables and flowers appeared to be in the sixth place.

Recently, promoting the production and export of horticultural products (fruits, vegetables and flowers) has caught the attention of the federal government of Ethiopia (Desalegn 2002). Yet, the share of horticultural export income is one of the lowest in the total export earnings. On average, horticultural export constitutes 1.71% of the total Ethiopian export value (see table 2). But there is a tendency of positive growth in the export of this sub sector, i.e., from 1.33% of the total export value in 1997 to 2.65% in 2005.

The share of Ethiopia in total Sub Sahara African (SSA) countries' horticultural export is only 0.2% (Desalegn 2002). Compared with Kenya, Desalegn indicates that Ethiopia's share in the total green beans export from the SSA countries is only 4.2% whereas Kenya's share is 48%. Moreover, not only the share, but also the number of horticultural products exported to other countries (except Djibouti[3]) is limited. Based on information from the International Trade Center (ITC), Desalegn (2002) states that flower and green beans are the only significant horticultural export commodities of Ethiopia from around 44 different horticultural products that are traded in the world market.

[3] Export to Djibouti is without any grading and standardization procedure especially on the export of vegetable commodities. The vegetable trade with Djibouti is similar to trade between two regions of a country except for the existence of two currencies.

METHOD OF ANALYSIS AND DATA

Method of Analysis

To analyze the current mix of exports of Ethiopia a portfolio analysis is performed. This approach was developed by Markowitz (1959) who used it to analyze financial markets. Love (1979) modified Markowitz's model to investigate trade diversification. Alwang and Siegel (1994) developed the model further and introduced the concept of marginal analysis.[4] The portfolio approach is used to determine the mix of agricultural export commodities that stabilizes the fluctuating earnings and promotes export growth. Although the portfolio approach is criticized for the implicit assumptions that the nation's assets are fixed and easily reallocated without any cost in the short-run (Stanley 1999), the use of marginal analysis to identify the contribution of each commodity to the total export variation is insightful.

The objective function in the portfolio approach is either to minimize risk given a desired level of income or to maximize income subject to a variance constraint. Mathematically

$$\underset{X_i}{Min}\ \mathrm{var}(R_T) \ \text{ subject to: } \sum_{i=1}^{N} X_i P_i \geq R^* \tag{1}$$

or

$$\underset{X_i}{Max} \sum_{i=1}^{N} X_i P_i \ \text{ subject to: } \mathrm{var}\left(R_T\right) \leq V^* \tag{2}$$

where var(R_T) is the total export revenue variance, X_i is the quantity of export commodity i, P_i is the world market price of i^{th} export commodity, and V^* and R^* are target levels of variance and revenues, respectively.

The variance of total export earnings, var(R_T), is expressed as

$$\mathrm{var}(R_T) = \sum_{i=1}^{N} w_i^2 \ \mathrm{var}(R_i) + 2\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \ \mathrm{cov}(R_i, R_j)\,; \textit{for } i \neq j \textit{ and } \sum_{i=1}^{N} w_i = 1 \tag{3}$$

where w_i is the share of commodity i in the total export value $(=P_iX_i/\ \Sigma P_iX_i)$, R_i is export earnings from commodity i (i.e. $R_i = P_iX_i$), var(R_i) is the variance of export earnings from commodity i and cov(R_i, R_j) is the covariance between export earnings from commodity i and j. From equation (3) it follows that there are two important factors that determine the overall variance of export earnings: the weighted sum of variances of individual export products and the weighted sum of covariances between export earnings of different export commodities. The first term indicates that the overall earnings variance can be reduced by increasing the share of export products with small earnings variance. Note that variation in export earnings may be due to variation in prices and/or quantities. Therefore, it is interesting

[4] The portfolio approach used in this paper is adopted from Alwang and Siegel (1994).

to compare the earnings variation of individual products with their respective variation in prices and quantities in order to learn what the cause of individual variation is. The second term of equation (3) is also interesting. A negative covariance between R_i and R_j helps to reduce the overall variation in export earnings since the relative income movement for the two export commodities (i and j) is in opposite direction. In other words, a reduction in the export earnings of commodity i is compensated by an income increment from commodity j, or vice versa.

If the world market prices for agricultural export commodities are exogenous for a given country, it should focus on the volume of export in aiming at relatively stable export earnings. Planning for different volumes and combinations of export commodities can mitigate the variation in annual export earnings due to commodity price fluctuations. Therefore, it is important to investigate the contribution of each commodity's export volume in the instability of total export earnings.

To assess the effect of marginal changes in export volumes on variability, we can use the procedure developed by Alwang and Siegel (1994). By taking the first order derivative of the expression for variance of total export earnings with respect to the share of each export commodity, computing the change in the share of each export commodity due to the change in its own volume of export, and using the chain rule, Alwang and Siegel (1994) derived the marginal change in the overall export earning variation due to a unit change in the volume of i^{th} export commodity as:

$$\frac{\partial Var(R_T)}{\partial X_i} = \frac{\partial Var(R_T)}{\partial w_i} * \frac{\partial w_i}{\partial X_i} = (1-w_i)\frac{P_i}{\sum P_j X_j}\left\{2w_i Var(R_i) + 2\sum_j w_j Cov(R_i, R_j)\right\} \quad (4)$$

This marginal change can be converted into an elasticity and expressed as

$$\in_{X_i}^{Var(R_i)} = \frac{\partial Var(R_T)}{\partial X_i}\frac{X_i}{Var(R_T)} \quad (5)$$

This elasticity measures how one percent change in the volume of the i^{th} export commodity results in the percentage change of the total export earning variability (Alwang and Siegel 1994).

Data

This study uses annual export data collected by Ethiopian Custom's Authority for the period of nine years[5] (1997-2005). After separating the agricultural and non-agricultural export commodities and considering the share of each commodity in the total export value, eleven (groups of) agricultural export commodities are selected for the analysis. These commodities are; cereals (CERL), coffee (COFF), cotton (COTT), fruits-vegetables and

[5] Though the authors agree that more observations are required for a robust and strong statistical inference, it was impossible to obtain a summarized export data set for longer years.

flowers (FRVF), hides and skins (HDSK), live animals (LAN), meat (MEAT), oilseeds (OLSD), pulses (PULS), spices (SPIC), and tea (TEA). The quantities are all in 100 thousand tons and the values are in 100 million Birr.

RESULTS

This section presents the results of the empirical analysis based on the portfolio model given in section 3. First, export income variation is compared to variation in the two different sources for variability in export income, viz. prices and volumes by calculating coefficients of variation (CV) for the different commodities. The advantage of using the coefficient of variation is that units of measurement do not affect it. This analysis connects to the first part of equation (3), the weighted sum of individual earnings variances. From figure 2 it follows that, except for coffee, most of the variations in export earnings are due to variation in quantities rather than prices of export goods. This finding is consistent with previous studies (Alwang and Siegel 1994). Fluctuating weather conditions, outbreaks of diseases and pests and lack or impossibility of storage are few of the possible explanations for the existence of variability in export quantities. Import regulations including sanitary and phytosanitary controls imposed on exports from developing countries could also contribute to variability in export quantities.

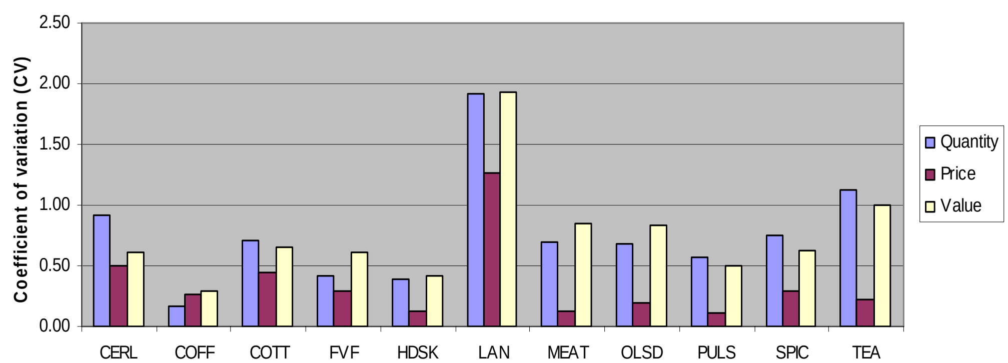


Figure 2. Variation in Ethiopia's export quantities, prices and values, 1997-2005.

Except for coffee, fruits-vegetables and flowers, and hide and skin, all the agricultural commodities have a CV of 0.5 or higher for the export quantities. The highest CV (1.92) is observed for the quantity of exported live animals. This is attributed to the ban on live animals due to Rift Valley Fever. Coffee has the lowest CV for quantity of export among all agricultural export commodities (0.17). Most of the variation in coffee export income (0.29) is due to variation in price (CV of 0.26). In general, the variation in prices of agricultural export goods is low compared to variation in quantities. For instance, except for coffee and cotton, all agricultural commodities have a CV of less than 0.30 for prices.

Table 3. Covariance Matrix for Agricultural Export Commodity Values, 1997-2005

	CERL	COFF	COTT	FRVF	HDSK	LAN	MEAT	OLSD	PULS	SPIC	TEA
CERL	0.284										
COFF	-1.087	36.851									
COTT	0.050	-1.082	0.194								
FRVF	0.169	0.746	0.069	0.257							
HDSK	0.453	-8.600	0.285	-0.091	2.962						
LAN	0.107	2.396	-0.010	0.262	-0.622	0.389					
MEAT	0.047	1.419	0.037	0.158	-0.347	0.216	0.139				
OLSD	1.027	11.826	0.443	2.042	-2.576	2.487	1.508	17.940			
PULS	0.317	-1.676	0.116	0.300	0.628	0.138	0.082	1.681	0.663		
SPIC	0.069	0.137	0.059	0.118	0.009	0.109	0.074	0.950	0.139	0.066	
TEA	0.010	0.068	0.023	0.024	0.004	0.018	0.018	0.193	0.025	0.014	0.005

Table 3 presents covariances of the selected export products. The second part of equation (3) indicates that is important to investigate whether covariances are positive or negative, since negative covariances help to reduce overall variation in export earnings.

Considering the nine years export data, it is found that only the export earnings from hide and skin have a negative covariance with the total export earnings. However, when the study period is divided into two, i.e., 1997-2001 as a first and 2002-2005 as a second period, earnings from oilseeds, pulses, fruits-vegetables and flowers, cotton, meat, and spices have a negative covariance with the total earning in the first period. Similarly, hide and skin, pulse and cotton also have a negative covariance with the total earnings in the second period. The remaining commodities in both periods have a positive covariance with the total export earnings. In other words, export earnings from these commodities have contributed to the total export income variability. For coffee this is of course not surprising since this is the major export product of Ethiopia, dominating total export revenues. The fluctuating and declining coffee price in the world market is therefore a major explanation for the total fluctuations in export income. Export income from agricultural commodities like oilseeds, hides and skins, pulses, cotton, fruits-vegetables and flowers, meat, and spices contributed towards reducing the total export earnings instability as their annual export incomes co-vary negatively with the total export income. Export income from these products also co-varies negatively with export earnings from coffee. To obtain a more balanced export portfolio, the shares of these agricultural export products should be increased.

The covariances of export earnings are analyzed in a more detailed way by looking at the relations between prices and export volumes. This is done by calculating correlation coefficients, which have the advantage of being unit free. Moreover, assuming that prices and volumes are normally distributed, the significance of the correlation coefficients can be tested. With respect to volumes, fourteen correlation coefficients were found to be significantly different from zero at the 5% critical level. In addition, all the significant volume correlation coefficients show a positive relationship. This is not surprising since there is an increasing trend in the volume of export in all agricultural commodities in the recent years. Price correlation is in this sense more interesting since it is exogenous to a country and its producers. Seven price correlation coefficients were found to be statistically different from zero (again assuming normality). Coffee and cotton, coffee and tea, tea and pulses, meat and oilseeds, and fruits-vegetables-flowers and live animals had positive price correlation coefficients. Export prices of oilseeds and cotton were both negatively correlated with the export price of spices in the given period.

Table 4 gives the marginal contributions and elasticities of the agricultural export quantities in the total earning instability. The marginal contribution indicates the overall change in the export income variation of Ethiopia due to an increment in the volume of the corresponding commodity. For instance, increasing the volume of coffee export by 100000 metric tons increases the total export income instability by 7.52, on average. The column with elasticities gives the percentage effect on the variance of export revenues of a one percent change in export quantity of particular commodities. In ranking the commodities in terms of their contribution towards reducing the total export income instability, hide and skin comes first whereas cotton and cereals are the second and third, respectively. An increase in the products with a high stability rank would have led to more stable export earnings in the period surveyed. However, the export of hides and skins can be severely constrained by the sanitary and phytosanitary regulations in the world market and this problem potentially could limit the expansion of its export. Therefore, focus should be more on commodities such as cotton, cereals and pulses. For comparison, the fourth column gives the ranking of export goods based on the share in the current export mix as given in table 2.

Table 4. The Marginal Contributions of Each Agricultural Export Quantity to the Total Earning Instability

Commodity	Marginal contribution [a]	Elasticity [b]	Rank in stability	Rank in share
Cereals	-0.0795	-0.0146	3	5
Coffee	7.5197	7.3052	11	1
Cotton	-0.1738	-0.0100	2	7
Fruit-veg. and flowers	0.0812	0.0180	7	6
Hide and skin	-7.6718	-0.5888	1	3
Live animals	0.4681	0.0171	8	10
Meat	0.6464	0.0130	9	9
Oilseeds	1.7126	1.2376	10	2
Pulses	-0.0777	-0.0372	4	4
Spices	0.0738	0.0031	6	8
Tea	0.0344	0.0002	5	11

Note: [a] The marginal contribution is computed from equation (4) above. [b] The elasticity is computed as indicated in equation (5) above and a multiple of 100 due to smaller digits.

DISCUSSION AND CONCLUSIONS

Most developing countries, including Ethiopia, are depending on the export of primary and traditional agricultural commodities for their foreign currency earnings. However, the world market prices for these commodities are fluctuating and even declining from time to time. Added to export volume fluctuations, such price fluctuations exacerbate export income instability. Therefore, it is important to examine the extent of total export income variability, major commodities contributing to the instability, and potential commodities that would mitigate the earnings instability.

A large amount of variation in Ethiopia's export income is attributed to fluctuations in coffee export income. This is due to the fact that the share of coffee in total export earnings is more than half and that the price of coffee in the world market was rapidly declining during the first six years period in this study. The dominating effect of coffee earnings on total earnings stresses the need for a more balanced export portfolio.

Looking at sources of variation for individual products it was found that all agricultural commodities except coffee have higher coefficients of variation in their export volumes than in their respective export prices. In other words, the lack of a stable supply of most export commodities has a more substantial effect on their earnings instability than fluctuations in world market prices.

Earnings of most agricultural export products had a negative covariance with earnings of coffee exports, thereby reducing the overall instability in earnings. Export volumes of cereals, cotton, pulses, hides and skins had a strong negative correlation with the volume of coffee. Fruits-vegetables and flowers had a strong negative price correlation with coffee.

The portfolio analysis indicates that hide and skin, cotton, cereals, and pulses contributed positively to the overall stability in the total export earnings. Increasing the quantity of these export commodities can reduce the total earnings instability in the future.

Overall, it can be concluded that there are various export products (traditional and non-traditional) that lead to a more balanced export portfolio, either because of negative volume or price correlation. One should note however that past price and volume fluctuations may change in the future. In other words, the results of this analysis are not a blueprint for the most optimal portfolio.

The main lesson to be learned is that a more balanced export portfolio is possible that leads to stable export earnings. In increasing the volume of certain agricultural export commodities with the aim of stabilizing foreign currency earnings, increasing sanitary and phytosanitary measures should also be taken into account. The direction of trade link with the developed world, which has strong food safety requirements, would have been reduced if there were strong regional trade with middle income countries exercising relatively lower safety standards. Regional trade is, however, less attractive for Ethiopia as the neighboring countries have more or less similar economies and almost the same comparative advantages, i.e. exporting similar agricultural commodities.

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MEXICAN HOUSEHOLD FOOD SHOPPING BEHAVIOR ACROSS SHOPPING FORMATS

***Hsiang-Tai Lee*[1], *Jill J. McCluskey**[*2] *and Jonathan K. Yoder*[3]**

[1] Dept. of Banking and Finance, National Chi Nan University, Taiwan, sagerlee@ncnu.edu.tw
[2] School of Economic Sciences and Food Policy Fellow, IMPACT Center, Washington State University, USA
[3] School of Economic Sciences, Washington State University, PO Box 646210, Pullman, WA 99164-6210, USA
509-335-8596, Fax: 509-335-1173, yoder@wu.edu

ABSTRACT

This article presents an empirical study of Mexican household food shopping behavior across various grocery formats, including outdoor market places, traditional Mexican “Mom and Pop” grocery stores, modern supermarkets, and super centers. A multivariate probit model is estimated via a quasi-maximum likelihood method. The results suggest that consumers shop more frequently at outdoor market places and small, family-owned businesses, known as “Mom and Pop” stores, if they are the primary shoppers in the household, if they are members of a large family, and if they are less educated. Younger consumers are more likely to shop at supermarkets and super centers. We also find that shoppers who frequent outdoor markets also shop at “Mom and Pop” stores, while shoppers who frequent supermarkets also shop at super centers.

Mexicans traditionally buy their meat, eggs, produce, and packaged foods in different specialized stores, visiting three or more shops in their food shopping excursions. However, Latin America has led the way among developing nations in the growth of supermarkets (Reardon et al., 2003), and large American and multinational corporations have expanded into Mexican retail food markets. These supermarkets and super centers carry larger product assortments, potentially charge lower prices, and create competition for the traditional grocery stores and outdoor markets. Three out of every ten pesos spent on food by Mexicans is spent at Wal-Mart (Reardon et al., 2003). On the other hand, since Mexican shoppers shop

[*] Corresponding author: Jill J. McCluskey PO Box 646210, Washington State University, Pullman, WA 99164-6210, 509-332-2834, Fax: 509-335-1173, mccluskey@wsu.edu

frequently, traditional stores may maintain their attraction to shoppers because of more outlets and hence lower travel costs.

Mexico's culture has traditionally revolved around "Mom and Pop" stores, known in Mexico as *tiendas abarrotes*. "Mom and Pop" stores are typically small, family-owned businesses, which allow purchases on credit, so shopping there may be a necessity for liquidity constrained shoppers who cannot obtain credit elsewhere. Although middle and upper income consumers may also shop at "Mom and Pop" stores, supermarkets and super centers are now a viable alternative for this income segment of the Mexican population.

Our motivation for this study is to understand the type of consumer who is shopping at new supermarkets and super centers, and to what extent these consumers still also shop at traditional outlets. To this end, this research presents an empirical study of household shopping behaviors across retail formats and investigates how household demographic characteristics affect food outlet selections. A multivariate probit model is estimated via quasi-maximum likelihood to estimate the contribution of household characteristics have on the choice of store format. This information may help retailers develop strategies for Mexico.

This article contributes to a growing literature on food shopping behavior. Key factors that have been found to affect food-shopping behavior include store characteristics and shopper characteristics. Store characteristics include location, prices, product variety, quality of service, quality of produce, and store environment. Shopper characteristics include a wide variety of characteristics such as personal preferences, cultural characteristics, income, and various demographic variables.

Huddleston, Whipple, and VanAuken (2004) examine consumer loyalty to food stores in the Midwestern United States and find that store loyalty is promoted by advertisements, a convenient store location, a large product assortment, friendly service, and conveniences such as 24 hour-a-day service and quick checkout. Low prices appear to be a factor that entice shoppers to a store but are not a key factor for customer loyalty. In a study of U.S. data, Messinger and Narasimhan (1997) identify that larger assortments become more important as one's opportunity cost of time increases. This is an explanation for why supermarkets, which have larger product assortments, are gaining popularity compared to the traditional grocery stores.

Various articles examine the relationship between shopper demographic characteristics and shopping behavior. Kahn and Schmittlein (1989) find that about one third of U.S. households are quick shoppers, who make frequent lower-expenditure trips and the others make relatively less frequent, higher-expenditure trips. Bawa and Ghosh (1999) study how family expenditures and the number of shopping trips are related to household composition and socioeconomic characteristics in U.S. markets. They assume households seek to minimize the sum of travel cost and the cost of holding goods in inventory, and conclude that households headed by individuals 55 years and over, households without working adults, larger families, and/or higher income households tend to shop more frequently than their counterparts. Kim and Park (1997) classify U.S. shoppers into "routine" and "random" shoppers. Routine shoppers have higher opportunity costs of time, which is often correlated with higher incomes, so they tend to revisit familiar grocery stores but do so less frequently and spend more per trip. In contrast, random shoppers face low opportunity costs of time and search more widely across stores and within larger stores for the best price.

Thiele and Weiss (2003) analyze consumer demand for food variety in Germany. Increased income and living in a larger city increase the demand for food diversity.

Interestingly, they find that increases in the number of children aged between 7 and 17 years and the housekeeping person is not additionally working outside the home also increase the demand for variety in food. A single male household consumes a smaller number of different food products. Ackerman and Tellis (2001) study cross-cultural differences between Chinese and Americans in terms of shopping behavior. They find that Chinese use multiple senses when examining unpackaged food, inspect more items, and take more time to shop than do Americans.

Kim and Jin (2001) compare the profiles of Korean shoppers of multinationals versus Korean discount stores. They find that a higher percentage of the shoppers who have full-time jobs tend to patronize the multinational discount stores. However, there are no significant differences between the two groups with respect to age, family size, education level, and income.

The above studies are generally restricted to comparisons of behavior within the same store format, i.e., they are limited to only supermarkets or to only discount stores. However, like our study, a small number of studies examine household choice across retail formats. Bhatnagar and Ratchford (2004) study competition for non-durable goods sales among supermarkets, convenience stores, and food warehouses in United States. They assume that consumers choose the retail format that provides the most attractive combination of price, assortment of products, and travel cost. They conclude that convenience stores charge a higher price but minimize travel time, supermarkets attract those shoppers who prefer larger product assortments, and food warehouses are preferred by the heavy users, such as consumers with larger families. Fox, Montgomery, and Lodish (2004) study U.S. consumer shopping choices among supermarket retailers, mass merchandisers, and drug stores, and find that consumers respond to variations in product assortments and promotions more than prices.

Two studies, perhaps most similar to ours, look at how changes in the availability of supermarkets and super centers affect choice among retail format in general. D'Haese and van Huylenbroeck (2005) provide a case study of the shifting purchasing patterns of two villages in rural South Africa. The majority of households in their study now buy their main food items from supermarkets rather than from local shops and farmers. Seiders, Simonides, and Tigert (2000) study the effects of super center market entry on local traditional food retailers in four U.S. cities. They find that consumers choose traditional supermarkets primarily for convenience, quality, and service, and choose super centers primarily for price and assortment.

This present paper contributes to the literature summarized above by providing an analysis of consumer choice from among traditional and newly available shopping formats in Mexico. It differs from previous research on shopper selection among market formats in at least two ways. First, we focus on a set of four different formats and examine the effects of personal demographic characteristics on format choice. Second, we use a quasi-maximum likelihood approach to estimate a multivariate probit regression of format choice, and this framework allows us to characterize correlation across these four format choices while controlling for demographic characteristics to draw some interesting conclusions about substitution among the two newer formats and the two more traditional formats.

The remainder of this paper is arranged as follows. In Section I, household shopping behavior is characterized with a multivariate probit model and a description of the quasi-maximum likelihood estimation method follows. Section II describes the data, and empirical results are presented in Section III. Section IV concludes.

I. MODEL

We characterize the choice among shopping formats by a multivariate binary choice model, which can be depicted mathematically as follows:

$$\mathbf{y}_i^* = \mathbf{X}\boldsymbol{\beta}_i + \boldsymbol{\varepsilon}_i \;; \qquad i = 1, 2, 3, 4; \qquad k = 1 \ldots N . \tag{1}$$

$$y_{i,k} = \begin{cases} 1 \text{ if } y_{i,k}^* > 0 \\ 0 \quad \text{otherwise} \end{cases},$$

where $\mathbf{y}_i^*$, is a N by 1 vector in which the k^{th} element $y_{i,k}^*$ represents the net benefit to the k^{th} shopper from the i^{th} shopping format, and N the number of shoppers sampled. The possible shopping formats are outdoor market places, "Mom and Pop" stores, supermarkets and super centers, represented by $\text{i} = 1, 2, 3, 4$, respectively. We do not observe $y_{i,k}^*$, but instead we observe whether the household shops at least once a month at the i^{th} market. The variable $y_{i,k}$ is defined to equal one when consumer k shops at least once a month in shopping format i, and zero otherwise. The matrix $\mathbf{X}$ includes a set of explanatory variables (N observations each) representing shopper characteristics and the location where the respondent was intercepted. Descriptions of the dependent variables are included in table 1. The vector $\boldsymbol{\varepsilon}_i$ contains N random disturbances drawn identically from a multivariate normal distribution, $N(\mathbf{0}, \boldsymbol{\Sigma})$, where $\boldsymbol{\Sigma}$ is a 4-by-4 covariance matrix with diagonal elements equal to one and off-diagonal correlations equal to $r_{i,j}$, where $(i, j) \in \{\ (1,2),\ (1,3),\ (1,4),\ (2,3),\ (2,4),\ (3,4)\ \}$.

We estimate the parameters of this model assuming a multivariate probit model and use the quasi-maximum likelihood (QML) method (Avery, Hansen, and Hotz, 1983; Kimhi, 1994). The QML method is consistent and asymptotically normal and only involves calculation of bivariate normal densities rather than k-dimensional normal densities, thereby reducing the computational burden substantially for estimation of high dimensional probit models. QML is a two-stage method. In the first stage, $\boldsymbol{\Sigma}$ is assumed to be diagonal and each equation is estimated by unit-variate probit. For market i, the coefficients can be estimated by maximizing the following log likelihood function

$$\ln L = \boldsymbol{\iota}^T \times \left\{ y_i \ln F\left(\mathbf{X}\boldsymbol{\beta}_i\right) + \left(\boldsymbol{\iota} - y_i\right) \ln\left[\boldsymbol{\iota} - F\left(\mathbf{X}\boldsymbol{\beta}_i\right)\right]\right\},\ i = 1, 2, 3, 4 \tag{2}$$

where $\boldsymbol{\iota}$ is a $N \times 1$ unit vector, T stands for transpose, and F is univariate normal cumulative distribution function.

After estimating coefficients $\boldsymbol{\beta}_i$ for each equation, the correlation structure of the markets can then be recovered in a second stage bivariate probit estimation. The correlations are estimated by maximizing the following log likelihood function

$$l = l_{12} + l_{13} + l_{14} + l_{23} + l_{24} + l_{34} \tag{3}$$

where

$$l_{ij} = \boldsymbol{\iota}^T \times \begin{bmatrix} y_i \cdot y_j \cdot \ln B\left(-\mathbf{X}\hat{\boldsymbol{\beta}}_i, -\mathbf{X}\hat{\boldsymbol{\beta}}_j, r_{ij}\right) + \\ y_i \cdot \left(\boldsymbol{\iota} - y_j\right) \cdot \ln B\left(-\mathbf{X}\hat{\boldsymbol{\beta}}_i, \mathbf{X}\hat{\boldsymbol{\beta}}_j, -r_{ij}\right) + \\ y_j \cdot \left(\boldsymbol{\iota} - y_i\right) \cdot \ln B\left(\mathbf{X}\hat{\boldsymbol{\beta}}_i, -\mathbf{X}\hat{\boldsymbol{\beta}}_j, -r_{ij}\right) + \\ \left(\boldsymbol{\iota} - y_i\right) \cdot \left(\boldsymbol{\iota} - y_j\right) \cdot \ln B\left(\mathbf{X}\hat{\boldsymbol{\beta}}_i, \mathbf{X}\hat{\boldsymbol{\beta}}_j, r_{ij}\right) \end{bmatrix}$$

and $(i, j) \in \{\ (1,2),\ (1,3),\ (1,4),\ (2,3),\ (2,4),\ (3,4)\ \}.$

where "·" denotes the element-by-element multiplication operator, and B is the bivariate normal cumulative distribution function.

Table 1. Summary Statistics for Demographic Variables and Household Shopping Frequency Across Grocery Format

Demographic Variables	Description (Coding)	Statistics
Gender	1 if male	40.3%
	0 otherwise	59.7%
Shopper	1 if main shopper	54.2%
	0 otherwise	45.8%
Children	1 if children under 18 in household	65.3%
	0 otherwise	34.7%
Family Size	1 if number in household is higher than 5	34.7%
	0 otherwise	65.3%
Education	1 if at least complete University	7.5%
	0 otherwise	92.5%
Employment Status	1 if full-time employed	43.6%
	0 otherwise	56.4%
Age	1 if greater than 35	34.9%
	0 otherwise	65.1%
Grocery Type	Percentage of respondents shops at least once a month	
Outdoor Market Place	67.1%	
"Mom and Pop" store	78.7%	
Supermarket	25.6%	
Super center	39.5%	

As is usual for discrete choice models, the estimated marginal effect of an explanatory variable on the probability of shopping in a given store format are functions of the estimated parameters and the data. Because the marginal effects in the multivariate probit model are complicated functions of data and parameters, and because our explanatory variables are binary dummy variables as described below, we generate estimated marginal effects numerically as follows:

First, we calculate the predicted probability for each store format for a benchmark set of characteristics. This benchmark is set for convenience such that all dummy variables are set to zero, which corresponds to an individual with the following characteristics: a young, less educated, unemployed female who is not the primary shopper with a small family size, and no child under eighteen in household.

Second, an individual dummy variable (for example, the gender dummy variable) is set to equal to 1 (all others set at zero) and the predicted probability for each store format is again calculated. This process is repeated for each dummy variable in each equation (each time with all other dummy variables set equal to zero). The estimated effect of a change in the dummy variable in the predicted probability of shopping in store format *i* is equal to

$$\frac{\Delta \hat{p}_i}{\Delta x_j} = \left(\hat{p}_i \,|_{x_j=1} - \hat{p}_i \,|_{x_j=0} \right) \tag{4}$$

where $\hat{p}_i$ denotes the predicted probability for the i^{th} store format, x_j is the j^{th} dummy variable in X, and all other dummy variables (not the j^{th}) are set to zero for both cases. Thus, the estimated marginal effect is the discrete change in the predicted probability with respect to a discrete one-unit change in one dummy variable, *ceteris paribus*, where the predicted probabilities in both the base case and the alternative case are based on the 4-variate normal distribution, with arguments $\left(\mathbf{X}\hat{\boldsymbol{\beta}}_{1,} \cdots \mathbf{X}\hat{\boldsymbol{\beta}}_{4,} \hat{\boldsymbol{\Sigma}}\right)$, where $\hat{\boldsymbol{\Sigma}}$ and parameter vectors $\hat{\boldsymbol{\beta}}_i$ are estimated by maximum likelihood as described above.

II. DATA

The survey used in this study was pre-tested with Spanish speaking students and conducted in Spanish at the following locations in Mexico: Aguascalientes; Leon, Guanajuato; and San Juan de Los Lagos, Jalisco, during May 2004. Aguascalientes is a large industrial state in central Mexico. It is also the capital of the state of the same name with a population around 640,000. Leon, Guanajuato has a population of around one million citizens and is said to be the shoe capital of the world because of its large number of factories producing shoes. San Juan de Los Lagos, Jalisco is a city with a population of approximately 40,000. San Juan de Los Lagos has a large concentration of hotels, and restaurants. Novelty items are sold on almost every corner in the city center.

The survey data were collected in-person at food outlets, including outdoor market places, "Mom and Pop" stores, and supermarkets.[1] Respondents were selected with the

[1] The super center locations did not allow interviews of their patrons.

criterion that the interviewer was to solicit every third customer who came in the survey area. Every respondent was offered a bottle of Coke (worth approximately U.S. \$0.50) as an incentive for participation in the survey. The refusal rate was about ten percent as observed by interviewers. The data set contains 544 completed surveys.[2] The survey collected information on household shopping frequency in outdoor market places, "Mom and Pop" stores, supermarkets and super centers, as well as information on household demographics. The demographic variable descriptions and summary statistics are presented in table 1. The majority of the respondents are female (59.74%), with age less than or equal to 35 years (65.07%), and with at least one child under 18 years living in their households (65.26%). Almost eight percent of the respondents have completed at least university education. The mode education level of the respondents is high school, which is higher than the Mexican mode level of education of less than high school (Encarta 2004). Almost 44 percent of the respondents are full-time employed. Fifty-four percent are the primary food shoppers of their households, and 34.74% of them have greater than five members in their households.

The statistics relating to household shopping frequency across grocery formats are presented in table 1. The percentage of respondents who shop at least once a month in outdoor market places and "Mom and Pop" stores are 67.1% and 78.7%, respectively. The respondents' shopping frequencies in supermarkets and super centers are much lower than that in outdoor market and "Mom and Pop" stores. Only 25.6% the respondent households shop at least once a month at supermarkets, and 39.5% shop at super centers.[3]

III. Empirical Results

Correlation coefficients shown at the bottom of table 2 provide an overview of the pattern of correlation for shopping across the four types of market outlets. All six correlations are significant at 99% significant level. We find that visitation rates for outdoor market places and "Mom and Pop" stores are positively correlated and visitation to supermarkets and super centers are also positively correlated. The rest of the correlations are all significantly negatively correlated. This implies that those who shop in outdoor market places frequently also shop in the "Mom and Pop" stores and shop relatively less frequently in supermarkets or super centers. Those who shop frequently at supermarkets are more likely to shop in super centers, but relatively less frequently at outdoor market places or "Mom and Pop" stores. The results suggest there are interrelationships among shopping formats. The newer food shopping formats bring competitive pressures on the traditional markets.

[2] Our data protocols were to exclude surveys in which the respondent did not answer the food shopping behavior questions.

[3] Note that since our sample is based on intercept surveys, these percentages to not reflect the population percentages. The sample percentages will likely be affected by the location where the respondent was intercepted.

Table 2. Parameter Estimation Results of Multivariate Probit Model

Outdoor Market Place (MPs)	Estimate	Standard Errors	t-ratios	Marginal Effect
Intercept	0.050	0.155	0.324	0.0021
Gender	0.077	0.132	0.582	0.0032
Shopper	0.293**	0.131	2.232	0.0120
Children	-0.020	0.075	-0.271	-0.0009
Family Size	0.312***	0.129	2.419	0.0127
Education	-0.477**	0.211	-2.258	-0.0183
Employment Status	-0.174*	0.122	-1.427	-0.0071
Age	0.234**	0.128	1.824	0.0096
Intercepted at Supermarket	0.232**	0.137	1.691	0.0096
Intercepted at Mom and Pop	0.288**	0.143	2.017	0.0118
“Mom and Pop” stores (MnP)	Estimate	Standard Errors	t-ratios	Marginal Effect
Intercept	0.849***	0.179	4.731	0.0346
Gender	0.064	0.138	0.465	0.0031
Shopper	0.153	0.139	1.100	0.0074
Children	-0.220*	0.135	-1.631	-0.0102
Family Size	0.333***	0.142	2.351	0.0159
Education	-0.286*	0.222	-1.285	-0.0131
Employment Status	-0.419***	0.130	-3.212	-0.0183
Age	0.111	0.140	0.787	0.0054
Intercepted at Supermarket	0.089	0.150	0.594	0.0043
Intercepted at Mom and Pop	0.147	0.156	0.946	0.0071
Supermarket (SM)	Estimate	Standard Errors	t-ratios	Marginal Effect
Intercept	-0.889***	0.182	-4.897	-0.0327
Gender	0.327***	0.136	2.406	0.0207
Shopper	0.032	0.146	0.219	0.0019
Children	0.261**	0.132	1.980	0.0165
Family Size	-0.257**	0.138	-1.864	-0.0140
Education	0.596***	0.215	2.768	0.0372
Employment Status	0.254**	0.127	2.007	0.0160
Age	-0.399**	0.140	-2.855	-0.0201
Intercepted at Supermarket	-0.098	0.142	-0.684	-0.0057
Intercepted at Mom and Pop	-0.113	0.150	-0.752	-0.0065
Super center (SC)	Estimate	Standard Errors	t-ratios	Marginal Effect
Intercept	-0.716***	0.166	-4.307	-0.0209
Gender	0.362***	0.130	2.783	0.0099
Shopper	0.288**	0.129	2.228	0.0081
Children	0.474***	0.124	3.806	0.0125
Family Size	-0.261**	0.127	-2.053	-0.0080
Education	0.820***	0.228	3.590	0.0185
Employment Status	0.112	0.119	0.938	0.0033
Age	-0.388***	0.128	-3.037	-0.0118
Intercepted at Supermarket	0.049	0.131	0.375	0.0015
Intercepted at Mom and Pop	-0.275**	0.141	-1.943	-0.0084
Correlation Coefficient	parameter	Standard Errors	t-ratios	
MPs and MnP	0.675***	0.027	25.049	
MPs and SM	-0.638***	0.030	-20.931	
MPs and SC	-0.494***	0.038	-12.951	
MnP and SM	-0.750***	0.024	-31.727	
MnP and SC	-0.426***	0.034	-12.705	
SM and SC	0.625***	0.029	21.263	

Note: single (*), double (**), and triple (***) asterisks stands for statistically significant at 10%, 5%, and 1% levels, respectively.

The positive correlation coefficient between outdoor markets and “Mom and Pop” stores was expected, given that outdoor markets specialize more in fresh fruit and vegetables, special crop products, livestock and poultry products, while “Mom and Pop” stores normally concentrate more on packaged food items, including bottled or canned products. This result indicates a complementary relationship between traditional outdoor markets and “Mom and Pop” stores. The negative correlation coefficient between both traditional formats (outdoor markets and “Mom and Pop” stores) and the modern formats (supermarkets and super centers) suggests substitute competitive relationships.

The positive correlation coefficient between supermarkets and super centers was unexpected. Since both formats offer a large variety of food products, one would expect for them to be substitutes. However, our results suggest that respondents who shop in these modern venues are likely to frequent both. Possible explanations are that shoppers are “cherry picking” advertised discounts at both formats or that they are choosing the venue based on occasion of consumption. More research is needed on this issue.

The parameter estimates and marginal effects estimated from the multivariate probit model are presented in table 2 above the correlation coefficients. The results are arranged equation by equation, starting with the equation for which the dependent variable is whether an individual had visited an outdoor marketplace recently and ending with the analogous equation for visiting a super center. The coefficients $\boldsymbol{\beta}_i$ and associated marginal effects relate to the effect of consumer demographics on the shopping frequency and indicator variables representing the location where the respondent was intercepted in each type of format.

The location indicators (*Intercepted at Supermarket* and *Intercepted at Mom and Pop*) are included to control for the fact that people who state that they have a preference for a particular type of store are more likely to be intercepted at their preferred format than others. Since no data were collected at super centers, the intercept term corresponds to data gathered at outdoor markets. The signs of the coefficients on these location indicators are generally what one might expect, in that if the respondent was intercepted at a supermarket they were more likely to state that they visited supermarkets at least once a month. They are also consistent with the correlation coefficients that show stronger positive correlation between shopping at newer formats and between more traditional formats.

Gender does not have a statistically significant effect on shopping at outdoor markets or “Mom and Pop” stores. Being male positively affects the likelihood that one shops at a supermarket or super center. For a given family size, the presence of children under eighteen years in the household has a positive effect on the likelihood that one shops at a supermarket or super center. However, conditional on the presence (or absence) of young children, shoppers with a household size of five or more people are likely to shop in outdoor market places and “Mom and Pop” stores more frequently. Having a large family has a negative effect on the probability that the shopper will frequent a supermarket or super center. It may be the case that shoppers with large families may be seeking to economize on their food budgets. Further, since shoppers with large families tend to shop more frequently, to save travel costs, primary shoppers and shoppers with larger families might shop more frequently in the traditional markets, which have more outlets than the modern supermarkets and super centers. Although supermarkets and super centers are gaining popularity in Mexico, they are mainly located in the upper and middle-income areas.

The coefficient estimates associated with full-time employment status are negative for the outdoor market place and the “Mom and Pop” stores and positive for supermarkets and super center (although not statistically significant at conventional levels for this latter variable), suggesting that full-time employees have higher opportunity costs of time and appreciate the convenience and variety of supermarkets and super centers. We also find that the education level affects where consumers shop for food. Based on the estimated marginal effects, individuals who have received a university degree are almost four percent more likely to shop at supermarkets and almost two percent more likely to shop at super centers than are people without a university degree, and are less likely to use outdoor market places or “Mom and Pop” stores at least once a month. Again, these results are consistent with the hypothesis that people with higher education levels generally have higher opportunity costs of time, and so should prefer one-stop shopping in the stores with more product variety. The associated marginal effects are not extremely large, but they might provide some guidance for varying marketing strategies among these groups.

Respondents’ age also affects shopping behavior. Our respondents who are older than 35 tend to shop in the outdoor markets and are less likely to shop in supermarkets or super centers. This result is consistent with the hypothesis that older shoppers tend to be more comfortable shopping in the traditional market formats in which customers and proprietors are more likely to be familiar with each other, whereas supermarkets and super centers are self-service stores and the transaction is anonymous compared with more traditional markets.

IV. CONCLUSIONS

Supermarkets and super centers are rapidly expanding in Mexico. These retail formats carry larger product assortments, charge lower prices, and create competition for the traditional grocery stores and outdoor markets. On the other hand, Mexican shoppers shop frequently, and traditional stores might attract shoppers because of more outlets and hence lower travel costs.

This research presents an empirical study of household shopping behaviors across retail formats and investigates how the household demographics affect their food outlet selections. We find that that older consumers tend to shop in the traditional markets and those with larger family sizes and with lower education level are more likely to shop in the outdoor markets and “Mom and Pop” stores. The positive correlation coefficient between outdoor markets and “Mom and Pop” stores suggests a complementary relationship between outdoor markets and “Mom and Pop” stores. The negative correlation coefficient between both traditional formats (outdoor markets and “Mom and Pop” stores) and the modern formats (supermarkets and super centers) suggests substitute competitive relationships. The positive correlation coefficient between supermarkets and super centers was unexpected. Since both formats offer a large variety of food products, one would expect for them to be substitutes. However, this was not the case, and more research is needed.

The marginal effects show that education level has the largest positive impact on the probability that shoppers will shop in the modern supermarkets and super centers, which implies that the opportunity cost of time might be the main factor that makes shopper choose modern supermarkets and super centers. Family size has a positive impact on the probability that shoppers will shop in the outdoor market places and "Mom and Pop" stores, which suggests that the travel costs and might be an important factor that makes shoppers shop in the modern supermarkets and super centers.

The results of this study should be of interest to food retailers in Mexico as they develop strategies to increase their competitive advantage through targeted marketing in a business environment in which shopping opportunities are expanding rapidly to provide more food shopping opportunities. The results suggest there are competitive interrelationships among shopping formats. Newer food markets bring significant competitive pressures on the traditional markets. Store characteristics such as location and accessibility may also be related to potential substitutability and complementarity among various formats, as well as consumers' demographics and shopping habits. Having a university education, full-time employment status, and being younger than 35 years increase the likelihood that a consumer will shop at more modern food outlets.

These results suggest that the traditional markets and small grocery stores may fill an important niche of providing fresh produce and meat until transportation infrastructures improve. Further, this analysis of new food shopping behavior in Mexico may have important implications for development economists and policy makers who are studying this country because it may contribute to their understanding of the demand consequences of the proliferation of new food shopping alternatives.

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Dragan Miljkovic
Editor, North Dakota State University
Department of Agribusiness and Applied Economics
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