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FOOD SAFETY STANDARDS AND EXPORT COMPETITIVENESS IN THE PROCESSED FOOD INDUSTRIES OF ASIA-PACIFIC COUNTRIES

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ABSTRACT

Developing country producers face several constraints related to food safety standards imposed by developed countries. This study identifies factors affecting export flows with respect to food safety standards and measures the effects of food safety standards on exports. The investigation uses data for processed food exports from 15 countries over 17 years.

The empirical results show that a one percent increase in food safety standards decreases exports by approximately one-half percent. Yet economic development in exporting countries can overcome higher food safety standards and will have a dominant effect over time as GDP increases for exporting countries.

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KEY WORDS: food safety, standards, aflatoxin, gravity model
JEL classifications: Q17, Q18

INTRODUCTION

International trade in food and processed food products has expanded enormously over the last ten years. World exports of processed food increased at the rate of 8.5% per year during 1970-2003, and the share of processed products in agricultural exports increased from 42% in 1990-91 to 48% in 2001-02 (Mohanty, 2006). The reason behind this upward trend in processed food exports is developed countries' changing food consumption patterns and the growing demand for "ready to eat" food.

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While the growth in demand for ready to eat food creates exciting opportunities for food processing industries, developed countries' environmental and health related requirements act as important non-tariff barriers to exports. Developing country producers face several constraints related to increasingly more stringent food safety standards imposed by developed countries. The U.S., the E.U., and Japan have strict requirements on food and processed food products. Differing standards across markets are another constraint. For example, chlorine is used in many countries to destroy pathogenic bacteria in food but in other countries it is completely forbidden in food contact applications.

The food safety concerns by developed countries are not without merit. A wide range of chemical substances including pesticides and additives are commonly used in food production and processing, and residues of these chemicals may remain in the end products. These residues can be harmful for humans, animals and plants, and the environment in which they live. So, consumers in developed countries have exhibited a high level of food safety concern related to their processed food supply, though their growing demand for "ready to eat" food has increased. Developed countries have increasingly called for assurances that food is free from substances such as pesticides, chemical additives, hormones, and antibiotics. However, the economic nature of the food safety issue in developing countries is somewhat different from developed countries. Their concern is about food safety regulations enforced by developed countries that act as important non-tariff barriers: these standards increase compliance costs of suppliers and thus reduce their export competitiveness.

Despite the concern of the term "food safety" in both national and global forums, little attention has been paid to examining its empirical relationship with international competitiveness. This study aims at reviewing challenges Asia-Pacific food exporters are facing in exporting to developed countries because of food safety standards. The purpose of this study is twofold: first is to identify factors affecting export flows with respect to food safety standards; and second is to measure the effects of food safety standards on exports from selected countries. The results of this study provide evidence on the impacts of important factors on food exports by less developed countries.

REVIEW OF LITERATURE

There are a considerable number of studies regarding food safety and international trade that range from theoretical and policy analyses to empirical analyses. However, empirical analyses of the impact of standards and technical regulations, in particular food safety standards, on export flows in the food and food manufacturing in Asia-Pacific countries are relatively sparse. The literature includes two types of studies; some perform case studies or surveys for policy analysis on food safety standards and the challenges exporting firms face due to increasingly more stringent food safety standards. Others employ econometric models to determine how domestic policies impact bilateral trade flows. The econometric approach which is most often used in the literature is the gravity model. Some investigators use the number of food standards in a country as a proxy for the severity of standards in the gravity model. Other investigators use more direct measures of food safety standards, but aggregating widely varying standards for a given importing country is difficult.

THE GRAVITY MODEL

The gravity model (Tinbergen (1962) and Linneman (1966)) is commonly used to determine whether a domestic policy positively or negatively influences the competitiveness of international trade. A number of authors set up domestic standards and technical regulations as proxies for their impact (environmental stringency) or severity (food safety standards) in the gravity model. Among the noteworthy works are Harris et al. (2002) for environmental policy impacts, and Jayasuriya et al. (2006), Wilson and Otsuki (2001), Otsuki et al. (2001), and Lacovone (2003) for food safety regulations.

Harris et al. (2002) investigated the relationship between environmental regulations and international competitiveness using the following gravity equation:

$$\begin{aligned}\ln IMP_{ijt} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} \\ &+ \beta_5 \ln DIST_{ij} + \beta_6 ADJ_{ij} + \beta_7 \ln EEC_{ijt} + \beta_8 \ln EFTA_{ijt} + \beta_9 \ln NAFTA_{ijt} \\ &+ \beta_{10} \ln LAND_i + \beta_{11} \ln LAND_j + \beta_{12} \ln SC_{it} + \beta_{13} \ln SC_{it} + u_{ijt}\end{aligned}$$

where, ln represents natural logarithm; IPM_{ijt} is the imports of country i from country j in year t; GDP_{it}, GDP_{jt}, the GDPs of country i and j, respectively, in year t; POP_{it}, POP_{jt}, the population of country i and j, respectively, in year t; $DIST_{ij}$, the distance between country i and j; ADJ_{ij}, , EEC_{ijt}, , $EFTA_{ijt}$, and $NAFTA_{ijt}$, are dummy variables identifying adjacency and trade agreements; $LAND_i$, $LAND_j$, the land areas of country i and j, respectively; SC_{it}, SCjt, are scores measuring the relative strictness of environmental regulations in country i and j, respectively, in year t; and U_{ijt} denotes the error term. They examined the effect of environmental stringency by six different indicators based on energy consumption or energy supply.

Jayasuriya et al. (2006) investigated the impact of increasingly stringent and differing standards set by developed countries on exports by India's food processing industries using a gravity model. They constructed an index to measure food safety standards through a survey of processed food industries. Their index was a weighted value of different groups of standards (including microbial hazards, pesticides, antibiotics, and toxic chemicals) in the importing countries relative to the Codex standard. Among the exporting countries, they found that food exported to EU countries, Australia and the US faced extremely restrictive standards, while exports of food to Canada and Japan faced moderately restrictive standards. They estimated that compliance costs averaged 5% of sales revenue, though they range from 10-15% for some food products. Based on their empirical results, they concluded that stringent food safety standards limit Indian processed food exports.

Using such an aggregated index for technical standards to determine impacts on trade flows has been found to have serious limitations. The aggregated index constructed from different standards has often produced empirical results inconsistent with conceptual expectations. For example, Swann (1996) and Moenius (1999) worked with two different standards -- as shared standards (where various standards were used as separate variables), and unilateral standards (where a number of standards are aggregated and formed into an index). Swann's findings suggest that shared standards positively impact exports, but had a little impact on imports; unilateral standards positively influence imports but negatively influence exports. Moenius found that shared standards have a positive impact on trade and unilateral standards enhance manufacturing trade, but limit trade in non-manufacturing sectors (Lacovone, 2003). Unfortunately, their proxy for the stringency of food regulations was the number of specific standards imposed by the importing country.

Lacovone's investigation suggests a way to overcome these shortcomings. He used maximum tolerated levels of aflatoxin B1, the most common and most toxic aflatoxin found in food, as a direct measure of the severity of the aflatoxin standard. He developed an extended gravity model to explain Latin American nut exports to Europe and found that there were substantial export losses to Latin-America from the tightening of the aflatoxin standards set by Europe.

Two other studies are supportive of using this direct measurement method. Wilson and Otsuki (2001) used a gravity model in their investigation on import flows of cereals and nuts. They concluded that these imports are negatively affected by the aflatoxin standard. Otsuki et al. (2001) also utilized a gravity model with the maximum aflatoxin level allowed measuring food safety standards in their analysis of African food product exports to EU counties. They concluded that tightening the aflatoxin level by EU countries reduces African food exports to the EU by 64 percent or US$ 670 million. They also found that the health risk in EU countries was reduced by approximately 1.4 deaths per billion a year due to these stiffer food safety standards.

MODEL SPECIFICATION

This study follows a gravity model approach which is derived from demand and supply functions of importing and exporting countries under general equilibrium conditions as reflected in Anderson and Wincoop (2003). The model assumes a CES (Constant Elasticity of Substitution) utility function for consumers in the importing country that is constrained by income. It is assumed that each country produces only one good and the supply of the good is fixed.

The consumers' demand equation for the imported good is derived by maximizing the consumers' utility function subject to the income constraint. The market clearing condition (aggregate import demand equals aggregate supply) is used to derive the profit function for the exporting country. Trade barriers and trade (transportation) costs (C_{ij}) are assumed to be a log linear function of bilateral distance (D) and adjacency or border (B) between importing and exporting countries.

These assumptions give the following gravity equation:

$$X_{ij} = g\left(\frac{I_i I_j}{\sum_j I_j}\left(\frac{D_{ij}B_{ij}}{P_i P_j}\right)^{\frac{1}{\rho}}\right) \tag{1}$$

where X_{ij} is exports from country i to j; I_i and Ij is total income of country i and j, respectively; D_{ij} is the distance from country i to j; B_{ij} is whether there is a shared border between i and j; P_i is the price in the exporting country and P_j is the price in the importing country; and ρ is the elasticity of substitution between all goods

Taking logs and appending error terms, we can write the following empirical form of the gravity model:

$$\ln X_{ij} = k + \ln I_i + \ln I_j + \tfrac{1}{\rho}\ln D_{ij} + \tfrac{1}{\rho}\ln B_{ij} - \tfrac{1}{\rho}\ln P_i - \tfrac{1}{\rho}\ln P_j + \mu_{ij} \tag{2}$$

In this empirical analysis, we incorporate a food safety standard variable with the expectation that this standard reduces a country's export competitiveness. The two price terms in the above equation (so called multilateral resistance variables) are not observable and difficult to measure so we did not use the terms but instead incorporate export and import price indices (Bergstrand, 1989). Including all these factors that explain bilateral exports, the extended gravity equation for this study has the following form:

$$\begin{aligned}\ln EX_{ijt} = \beta_0 + \beta_1 \ln GDP_{ti} + \beta_2 \ln GDP_{jt} + \beta_3 \ln Dis_{ij} \\ + \beta_4 \ln EPI_{it} + \beta_5 \ln IPI_{jt} + \beta_6 \ln FSS_i + \varepsilon_{ijt}\end{aligned} \tag{3}$$

where, GDP_{ti} is per capita GDP of country i at time t; GDP_{jt} is per capita GDP of country j at time t; Dis_{ij} is distance between country i and j; EPI_{it} is export price index of country i at time t; IPI_{jt} is import price index of country j at time t; FSS_i is the food safety standards in terms of aflatoxin with maximum allowable level imposed on imports by country i; and ε_{ijt} is an error term assumed to be normally distributed.

Equation (3) is the classical double-log specification, and the explanatory variables used in this model have a direct relationship to bilateral export flows. In this model, GDP_i measures the potential demand of the importing country, while GDPj represents the potential supply of the exporting country. Therefore, the corresponding slope parameters, β_1 and β_2, are expected to be positive. The rational for geographical distance is that a higher distance between trading partners leads to higher transportation costs and increased differences in preferences. Dis_{ij} is a proxy for resistance to trade, thus it is anticipated that β_3 will be negative. The slope parameter β_4 is expected to be negative because exporter's high prices reduce outward trade flows. On the other hand, it is anticipated that β_5 will be positive because importer's increased prices may cause foreign goods to be more competitive so inward trade flows rise (Bergstrand, 1989). Finally, FSS_i measures how strict the food safety standards are in importing countries; in line with the assumption that strict standards lead to relatively lower exports. In this model, the strictness of the standards depends on the tolerable level of aflatoxin B1: a lower level of aflatoxin standard indicates a more restrictive standard. Therefore, we anticipate that β_6 will be positive, which implies stiffer standard impact exports negatively.

DATA SOURCES AND DESCRIPTIONS

This study focuses on the factors affecting bilateral trade with special attention on the impact of food safety standards for different importing countries. The gravity model used in this study requires the following data for each country: exports of food and food products as dependent variables, country's total GDP, per capital GDP, population, geographical distance, export price index, import price index, membership in European Union (EU) and food safety regulations in terms of aflatoxin standards. The data utilized in this model are collected for seventeen years, 1988-2005, on 15 countries that include OECD and Asia-Pacific countries. The exporters are China, Fiji, Indonesia, Nepal, Sri Lanka, and Vietnam; the importers are Australia, Austria, Canada, France, Germany, Italy, Japan, United Kingdom, and the United States.

Data for bilateral trade, in particular the value of exports and imports of food and food products in US dollars under the classification of SITC Rev.3, are collected from United Nations Statistics division available online at http://unstats.un.org/unsd/comtrade/

Each country's Gross Domestic Product (GDP) and per capita GDP (both in constant 2000 US dollars) are collected from World Bank Development Indicator (WDI) available online at http://devdata.worldbank.org/dataonline/. Each country's population is collected from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2004 Revision and World Urbanization Prospects: The 2003 Revision, http://esa.un.org/unpp

Data for geographical distances are collected on the basis of the average distance between the major sea ports of the two countries. Since there are no waterways in Nepal we used the distance to Calcutta (including road distance in miles from Calcutta to Katmandu) for the country, Nepal. The data for distance are measured in nautical miles, and collected online at http://www.distances.com/ . The export price index of the exporting countries and the import price index of the importing countries are collected from World Bank Development Indicator (WDI) available online at http://devdata.worldbank.org/dataonline/

To measure the effect of food safety standards on trade flows we use aflatoxin standards as an explanatory variable. This is not a perfect measure for food safety standards, but it is a ratio-measured variable that is available for many countries. The data for maximum allowable levels of aflatoxins in parts per billion (ppb) appear in Table 1. These data are obtained from the FAO publication, "Worldwide Regulations for Mycotoxins 1995: A Compendium." Aflatoxins are present in foods as natural contaminants and cannot be completely excluded from the food chain. The most potentially toxic aflatoxin is designated as aflatoxin B1, and causes acute toxicity in animals and humans (Otsuki et al., 2001). In this context, the maximum allowable level of aflatoxin B1 imposed for food and food products is considered to determine the level of food safety standards in a country: the greater values of aflatoxin B1 in foods implies a more lax standard.

Table 1. Maximum tolerated levels of aflatoxins in food and food products.

Country	Maximum tolerated levels of aflatoxins (*ppb*)		Country	Maximum tolerated levels of aflatoxins (*ppb*)	
Australia	5	For all foods	India	30	For all foods
Austria	1	For all foods	Italy	5	For all foods
Canada	15	For nuts	Japan	10	For all foods
France	10		UK	4	For nuts and figs
Germany	2	For all foods	USA	20	For all foods

Source: Food and Agriculture Organization of the United Nations, 1997

EMPIRICAL RESULTS

We use data for bilateral exports of all food and processed food products, and data for factors affecting bilateral export flows for 17 years on 15 OECD and Asia-Pacific countries. The Akaike Information Criterion (AIC), Q statistics and Lagrange multiplier tests were used to determine the optimal model structure. Using AIC, the import price index variable was dropped from the model because it added virtually no explanatory power and was correlated with other independent variables. This model estimated with ordinary least squares had a high R2 (0.57), but was found to suffer from heteroskedasticity and serial correlation. The heteroskedasticity problem was associated with the exporting country's GDP and a second-order autocorrelation process was found for the error terms. The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) method in SAS was used to correct these problems and to obtain the model parameters.

Table 2. Regression results of bilateral exports in the food and food product sector.

Variable	Paramete restimates	Standard Error	t Value	Pr > |t|
Intercept	-20.64	1.57	-13.16	<0.0001
Exporter' s per capita GDP (GDPX)	1.96	0.05	38.57	<0.0001
Importer' s per capita GDP (GDPM)	0.44	0.13	3.31	0.0009
Distances (DIST)	-0.53	0.15	-3.62	0.0003
Exporter's export price index (EPIX)	0.98	0.01	74.29	<0.0001
Food Safety Standard (FSS)	0.52	0.16	3.30	0.0001

All variables are in logs. All coefficient estimates are significantly different from zero at the 1% level.

The estimation results are reported in Table 2. The parameter estimate on the policy variable (aflatoxin B1) is positive and statistically significant at the 1% level. Since a larger coefficient for aflatoxin B1 implies relaxation of aflatoxin contamination, the positive sign of the coefficient implies that the bilateral trade increases with relaxation of the standard. Because a double-log specification is used in the model, the coefficient is the elasticity, suggesting that a 1% tightening of the standard reduces bilateral exports by 0.52%. Jayasuriya et al. (2006) found that Indian food exporters received significant losses from stringent food safety regulations. This result is also consistent with the findings of Lacovone (2003) and Otsuki et al. (2001).

The coefficient for the exporter's per capita GDP is positive and significant at the 1% level. A 1 per cent increase in per capita GDP for the exporting country increases their exports by 1.96%; indicating that higher GDP in the exporting country results in markedly higher exports – possibly from better infrastructure to support exports, higher quality products, and a better image for the country as a whole. Developing countries that grow rapidly will have faster export growth for food products. The coefficient for the importing country's per capita GDP is significantly positive at the 1% level. A 1 per cent increase in the per capita GDP in the importing country is associated with 0.44% increase in exports. Economic growth in the more developed importing countries will increase food imports, but the elasticity is less than unity.

The other important coefficient from the gravity model is for distance (DIST), which had the expected negative sign (-0.53) and was significant at the 1% level. The coefficient indicates that a 1 percent increase in distance reduces food exports by 0.53%; not a large amount, but still an important deterrent to increased food exports.

The exporter price index (EPIX) is positively and significantly related to exports, which was not expected. It is likely that the exporter price index is picking up the development process of the exporter where higher prices reflect improved product quality and a better reputation for the country's products. Because of the aggregate nature of food exports there was no variable available to measure accurately the price for specific food products, so the unexpected sign for this coefficient is not surprising. It is likely picking up the positive impacts of development on prices and exports.

The effects of food safety regulations seem rather small, but one must remember that food standards can change drastically for a country. Moving the aflatoxin tolerance from 20 (the US's standard) to 4 (the UK's standard) is a 500% increase in the standard. Thus, if the US adopted the UK's food safety standards, exports to the US by the countries in this analysis would be only 45% of what they were before – a tremendous decrease. This would seriously impair developing country food exporters.

CONCLUSION

In this study, we estimate a model based on an extended gravity model to determine the possible influence of food safety standards on export flows of six Asia-Pacific countries to nine importing countries. The major question that surfaces from imposing food safety regulations in importing countries is whether and what extent are exports in the food and processed food industry influenced by the food safety regulations?

The empirical results show that the value of exports in food and food products is negatively affected by aflatoxin standards: the greater the food safety standards, the lower its restrictiveness, and higher the bilateral export flows. A one percent increase in food safety standards decrease exports by approximately one-half percent. This means that large changes in food standards (which are common these days) will have salutary, deleterious impacts on food exports by developing countries. Yet economic development in exporting countries can overcome higher food safety standards and will have a dominant effect over time as GDP increases for exporting countries.

Policies that will increase economic activity in the exporting and importing countries (specifically their GDPs) will increase food exports by developing countries in the years ahead. Despite all of the contraints and challenges Asia-Pacific exporters face in meeting food safety regulations, exports of food and processed food products have grown for the region and they are set to increase further in the future as incomes grow. So despite increased food safety standards, less developed countries that can improve infrastructure, product quality, and supplier reputation can find good markets for their food exports to more developed countries.

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THE GLOBAL IMPACT OF THE CIMMYT WHEAT BREEDING PROGRAM

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ABSTRACT

This paper quantifies the increase in wheat production in Mexico's Yaqui Valley from CIMMYT's breeding and development of semi-dwarf wheat varieties for the period 1990-2002. The costs and benefits of the wheat research program are estimated and evaluated using a two-region model of the world wheat market. The economic rate of return of the wheat breeding program at CIMMYT is calculated, and policy implications are derived. Estimates of the Internal Rate of Return of the CIMMYT breeding program were 51.4% during the 1990-2002 period, with a benefit cost ratio of 14.97, implying that for each dollar of public funds invested in CIMMYT wheat breeding research over the time period, 15 dollars of benefits result.

Key words: Public wheat breeding, benefit/cost analysis, agricultural research, wheat varieties.
JEL classification codes: Q17, O19

INTRODUCTION

The Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) is a nonprofit maize and wheat breeding research center based in El Batan, Mexico. CIMMYT was created to establish international networks to improve wheat and maize varieties in low-income countries.

CIMMYT research in wheat breeding has resulted in higher yields for global wheat producers over the past several decades. The sources of this investment in research include

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federal governments, nonprofit organizations, and grants from organizations such as the Gates Foundation. This study addresses the question, what are the welfare economic impacts of this research effort? Specifically, we determine whether the public investment in CIMMYT wheat breeding has resulted in a socially worthwhile use of limited public funds, and how the economic benefits of the research program are distributed across consumers and producers both in Mexico and throughout the world. The results of this study are particularly important in an era of declining public funds for public agricultural research (Fuglie et al., 1996; USDA Cooperative State Research Service, 1993). CIMMYT, a public breeder, has experienced a substantial decrease in funding from roughly 12 million (2002) USD in 1990 to approximately 6 million USD in 2002 (CIMMYT 2002). Careful measurement of the economic rate of return of the investment in wheat breeding research provides crucial information to administrators and policy makers, whose decisions on the allocation of research funding will determine the future size and scope of publicly funded agricultural research.

This paper extends previous research by Lantican et al. (2005) and Heisey et al. (2002), who estimated the cost-benefit analysis of the CIMMYT breeding program. By incorporating a more encompassing production function when estimating genetic yield growth, this paper extends and updates these earlier works. Estimation of the annual genetic yield growth attributed to CIMMYT is the basis for the cost-benefit analysis in both the Lantican et al. (2005) and Heisey et al. (2002) studies as well as this paper. This study uses a Just-Pope production function coupled with daily climatic data such as temperature, solar radiation, various planting methods, and specific species to provide a more precise estimation of the annual genetic improvement attributed to CIMMYT. The flexible Just-Pope production function is advantageous in this study for its ability to correct for multiplicative heteroscedasticity, which is important when using data obtained through varietal trials dealing with multiple varieties. This flexible production function is preferred to existing OLS models in varietal trials because of the variations in both the species and breeding goals across cultivars. Since cultivars are intended to be sown worldwide and are specifically bred for different pathogen resistance and agronomic conditions, the error terms across cultivars may be heteroscedastic.

The Just-Pope production function was estimated to obtain the annual genetic gain. Yield gains were measured for all semidwarf varieties tested by CIMMYT in their experiment station in Mexico's Yaqui Valley. From the Just-Pope model an increase in yield is estimated representing an increase in the supply of wheat produced in Mexico, and this estimate is the foundation of the economic impacts of the wheat breeding program.

The Just-Pope yield growth estimates are then incorporated in an economic model of the world wheat market measuring the impact of the CIMMYT wheat breeding program on: (1) Mexican wheat producers; (2) Mexican consumers of wheat (flour millers); (3) wheat producers outside of Mexico, including significant foreign producers such as the United States (USA), European Union (EU), Canada, Argentina and Australia; and (4) all wheat consumers outside of Mexico, including major wheat importers such as China and Japan.

From the economic model of the world wheat market annual benefits to specific groups resulting from the increased wheat yields, calculated in the Just-Pope production function, were derived. Several measures (cost-benefit, internal rate of return, and net present value) of the outcome of the investment in wheat breeding were likewise calculated.

FUNDING OF CIMMYT WHEAT BREEDING RESEARCH

CIMMYT, a non-profit organization, distributes improved germplasm to National Agricultural Research Systems (NARS) for worldwide utilization. Through the release of modern wheat varieties, CIMMYT has generated substantial increases in grain yields, improved grain quality, reduced yield variability, and reduced environmental degradation in low-income countries since the Green Revolution. On average, 65–77% of these international nurseries samples were sent to developing countries. CIMMYT germplasm is present in roughly 24% of all wheat types using the cross rule, 38% using the cross or parent rule, 64% using the any ancestor rule, and approximately 80% of the total spring wheat area in developing countries (Lantican et al. 2005).[1] Private wheat breeders have little incentive to breed in most low-income countries. CIMMYT fills this gap, and as a result, approximately 62% of the total wheat area in low-income countries is planted to CIMMYT-related varieties (Heisey et al. 2002).

Roughly 33% of CIMMYT's funding in 2002 was from governments and agencies including, United States (23%), The World Bank (23%), Switzerland (10%), the European Commission (9%), and the Rockefeller Foundation (8%). Japan, The UK, France, Australia, and other foundations made up the remaining 27% of the funding from governments. Nearly two thirds of CIMMYT's funding is obtained from grants and targeted funding from institutions like the Gates Foundation. The 2002 CIMMYT annual report disaggregated the budget into spending by individual divisions within CIMMYT. Approximately 33% of CIMMYT's budget went to germplasm improvement (breeding), 26% to sustainable production, 23% to enhancing national agricultural research systems, 14% to germplasm collection, and 4% to policy. While breeding expenditures received the largest share of the budget, most of CIMMYT's budget went to enhancing other goals.

CIMMYT conducts research in both wheat and maize and with the recent advances in maize breeding and the comparatively large increases in yield, money is being shifted from the wheat to the maize sector of CIMMYT. While overall funding at CIMMYT has been decreasing, wheat has experienced the largest loss. In 1990, the wheat breeding budget at CIMMYT was approximately $12 million (2002 USD), compared to just 6 million in 2002, and down from a high of $15 million (2002 USD) in 1988 (Lantican et al. 2005). The importance of public funding, coupled with the current political climate of decreasing public sector support (Acker, 1993), have resulted in a situation where continuation of public funding for the wheat-breeding research program is dependent on how well the program is serving the public.

[1] The term "CIMMYT cross" refers to a cross made at CIMMYT and the selections to obtain fixed lines that were either made at CIMMYT or by a non-CIMMYT breeding program. The term "CIMMYT parent" refers to a cross made by a non-CIMMYT breeding program using one of the parents coming directly from CIMMYT. Lastly, the term "CIMMYT ancestor" means that there is CIMMYT pedigree somewhere in the wheat, so CIMMYT wheat is not used directly in the cross, but was used in developing one of the parents.

MEASUREMENT OF THE SOCIAL BENEFITS OF CIMMYT WHEAT BREEDING

The methodology used to calculate the economic consequences of the CIMMYT wheat breeding program follows a rich literature in the welfare economics of agricultural research initiated by Schultz (1953) and further developed by Ayer and Schuh (1972) and Akino and Hayami (1975). More recently, the economic evaluation of agricultural research has been summarized by Huffman and Evenson (1993) and Alston et al. (1995).

The first step in evaluating the economic impact of the CIMMYT wheat breeding program was to measure the increase in yields from the genetic improvement of wheat, holding all other production parameters constant. Gains in wheat yield can be attributed to two factors: genetic and agronomic. Agronomic gains are attributed to improvements in fertilizer, pesticides, fungicides or other factors that are not embodied within the seed. Genetic gains are associated with improved wheat breeding, technology that is embodied within the seed. This study will focus on the estimation of genetic gains attributed to CIMMYT. This was accomplished by applying the methodology of Traxler et al. (1995) to calculate the relative yields for each variety with data from CIMMYT wheat variety performance tests in Mexico's Yaqui Valley experiment station from 1990-2002. A total of 33 lines were analyzed with release years ranging from 1962-2001, including the variety Siete Cerros, the most popular semidwarf wheat of the Green Revolution. Thus, the test period for this data set is 1990-2002 but includes lines released prior to 1990. Using relative yield performance data from nurseries implicitly assumes that actual producer yields are equivalent to test plot yields in CIMMYT experiments. Although the absolute level of producer yields may be overstated by experimental yield data, the relative yields between varieties are likely to be similar in both experimental and producer fields. Brennan (1984) reported, "The only reliable sources of relative yields are variety trials" (p. 182).

The present study follows previous evaluations of wheat breeding programs conducted by Traxler et al. (1995) who analyzed ten wheat lines released in Mexico from 1950-1985. Their goal was to analyze if CIMMYT released lines had progressively increased yield, improved yield stability, or both over time. Traxler et al. implemented a Just and Pope (1979) production function that estimates both output and output variance. The Just and Pope production function was chosen due to its ability to account for multiplicative heteroscedasticity. The multiplicative heteroscedastic correction is of importance to this data set because of the variations in both the species (durum, bread wheat, and triticale) and breeding goals across CIMMYT wheat varieties.[2] That is, since CIMMYT varieties are intended to be sown worldwide and are specifically bred for different climatic, physical, and agronomic conditions, the error terms across varieties may be heteroscedastic in nature. By accounting for this multiplicative heteroscedastic error term, comparisons across varieties are more statistically appropriate.

The Just and Pope production function can be described as such:

[2] The goals for breeding a specific wheat variety vary and can target a specific certain climatic conditions (drought tolerance, heat stress, etc.) or target a specific physical attribute (increased biomass, increased straw, etc.).

(1) $$Y_i = f(\mathbf{X}_i, \beta) + g(\mathbf{X}_i, \alpha)\varepsilon_i$$

where Y_i is yield of the ith variety , the $\mathbf{X}_i$ are explanatory variables (weather, species, planting methods, year variety i was released, etc.) , β and α are parameter vectors, and ε_i is a random variable with a mean of zero. The first component of the production function $f(\mathbf{X}_i, \beta)$ relates the explanatory variables to mean output. The function $g(\mathbf{X}_i, \alpha)\varepsilon_i$ relates the explanatory variables to the variance in output. The Just and Pope production function is a multiplicative heteroscedasticity model, which is estimated using a three-stage procedure. If variance is an exponential function of K explanatory variables, the general model with heteroscedastic errors can be written as:

(2) $$Y_i = X_i^{'}\beta + e_i, \quad i = 1,\ 2, \ldots ,N$$

(3) $$\mathrm{E}(e_i^2) = \sigma_i^2 = \exp\left[\mathrm{X}_i{}'\alpha\right]$$

where $X_i = (x_{1i}, x_{2i}, \ldots, x_{ki})$ is a vector of observations on the K independent variables. The K x 1 vector $\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_k)$ represents the unknown coefficients. $\mathrm{E}(e_i) = 0$ and $\mathrm{E}(e_i e_s) = 0$ for $i \neq s$. Equation (3) can be rewritten as

(4) $$\ln \sigma_i^2 = X_1^{'}\alpha$$

where the σ_i^2 is unknown, but using the least squared residuals from equation (2) the marginal effects of the explanatory variables on the variance of production can be estimated such that:

(5) $$\ln e_i^{*2} = X_i^{'}\alpha^* + u_i$$

where e_i^* is the predicted values of e_i and where the error term is defined as:

(6) $$u_i = \ln\left(\frac{e_i^{*2}}{\sigma_i^2}\right).$$

The predicted values from equation (5) are used as weights for generating generalized least squares (GLS) estimators for the mean output equation (2). That is, the estimates from equation (5) can be viewed as the effects of the independent variables on yield variability. The predicted values from equation (5) are then used as weights when re-estimating equation

(2). The results from the re-estimation of equation (2) with the weights from equation (5), give the effects of the independent variables on yield.

In the Just and Pope production function the yield mean is specified as a function of the release year of each variety tested, which can be interpreted as the "vintage" of the wheat breeding technology (Traxler et al. 1995). The year each variety was released to the public captures the progression of wheat breeding technology across time forming the main variable for measurement and analysis of the impact of the CIMMYT wheat breeding program on wheat yields in performance fields. As such, the coefficient on release year represents the average increase in yield due to genetic gains attributable to the CIMMYT wheat breeding program.

Release year is not a time trend variable but is modeled similar to the way that Arrow's (1962) growth model denoted embodied technology (Traxler et al. 1995). Arrow (1962) assigned "serial numbers" of ordinal magnitude to the embodied technology in capital. In the Just and Pope model the variable release year, represents the embodied technology for a given year of release by the CIMMYT breeding program. Therefore, the coefficient on release year possesses both a cardinal and ordinal significance in defining the spacing as well as the sequencing of releases (Traxler et al. 1995). The estimated equations for yield (Yi) in kg/ha and the log variance of yield $\left(e_i^2\right)$ using the Just and Pope production function are modeled in equations (7) and (8):

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 RLYR + \beta_2 Temp + \beta_3 Solar + \beta_4 Stress + \beta_5 HeatTemp + \beta_6 RLYR^2 + \beta_7 RLYRSolar + \\ & \beta_8 RLYRMeanTemp + \beta_9 RLYRHeatStress + \delta_1 BedsPlus + \delta_2 BedsMinus + \delta_3 Nets + \\ & \delta_4 Durum + \delta_5 Triticale + \varepsilon_i, \end{aligned} \tag{7}$$

and

$$\begin{aligned} \ln(e_i)^2 = {} & \Phi_0 + \Phi_1 RLYR + \Phi_2 Temp + \Phi_3 Solar + \Phi_4 Stress + \Phi_5 HeatTemp + \Phi_6 RLYR^2 + \Phi_7 RLYRSolar + \\ & \Phi_8 RLYRMeanTemp + \Phi_9 RLYRHeatStress + \gamma_1 BedsPlus + \gamma_2 BedsMinus + \gamma_3 Nets + \\ & \gamma_4 Durum + \gamma_5 Triticale + \varepsilon_i. \end{aligned} \tag{8}$$

Here mean and variance of yield were modeled as a function of their planting method: melgas with fungicide (MelgasPlus), beds with fungicide (BedsPlus), beds without fungicide (BedsMinus), and melgas with fungicide and nets (Nets). MelgasPlus was chosen as the default because it is the traditional planting method in the Yaqui Valley. Yield mean and variance were also modeled as a function of the species of wheat; bread (Bread), durum (Durum), and triticale (Triticale). The species were represented by binary variables with Bread used as the default.

Yield was modeled as a function of specific climatic variables because Fischer (1985) found that both solar radiation (Solar) and temperature (Temp) are important in determining the number of kernels per square meter. The theory is that just before and after anthesis is a sensitive period in wheat production, and both radiation and temperature have an effect on kernels per square meter and thus yield. High radiation results in increased photosynthesis, which is advantageous for yield. A high temperature has negative impacts on yield, as it shortens the duration of the spike growth period.

A heat stress (Stress) variable was used to indicate the number of days in the growing season (January – April) when the temperature was at or exceeded 36o C (96.8 o F). This heat stress variable is included because in the maturation months of March and April, if the temperature is too hot, the wheat kernel can scorch, negatively impacting yield. Lastly, the interaction variable (HeatTemp) was created by multiplying (Stress) by the average temperature during the same growing season (January – April). This was included to capture the potential of a growing season where temperature is well below average, implying that heat stress may adversely affect yield more under these conditions than a growing season with an average temperature well above average. The interaction between RLYR and the weather attributes was included because a priori it can be assumed that the various types of varietal improvements, and thus lines, may have been targeted towards certain weather conditions (drought tolerance, heat stress, etc.).[3] The interaction between certain weather characteristics and RLYR can be seen as slope shifters.

The Just and Pope regression results come from Nalley et al. (2007) who used the same data set to determine the annual genetic improvements attributed to CIMMYT. The shift in wheat production (Jt), which is equivalent to the coefficient on release year in the Just and Pope model, is the foundation for the analysis of the economic impacts of wheat breeding research.

An important aspect of a breeding program is its cumulative benefits over a specific period. That is, the genetic enhancement received in time period t are those observed in t plus those seen in t-1 as well. Therefore in this data set, the additional genetic benefits for 2002 (J2002) would be the genetic gain from 2001 to 2002 plus the genetic gain from 1990 to 2001. Thus the shift in wheat production in 2002 would be a cumulative shift from 1990 to 2002.

Previous work by Echeverria et al. (1989) also used experimental yields to measure research-induced industry supply curve shifts for rice in Uruguay. Alston et al. (1995) demonstrated how to convert an annual shift in the quantity of wheat produced (Jt) into a percentage shift in cost savings (Kt): the formula is Kt = Jt/ε, where ε is the elasticity of supply of wheat (page 339).

A global analysis for total acres planted to CIMMYT varieties is possible since CIMMYT publishes rough estimates on regional acres planted to CIMMYT varieties. A precise measure of the benefits of the CIMMYT breeding program would include all global acres planted to CIMMYT lines. CIMMYT's regional acreage groupings (North Africa, West Asia, etc.) tend to be rough estimates for areas and in most instances are not disaggregated on a country level, making a precise international trade model difficult to implement. Because of this, the current study will only analyze the effects of CIMMYT varieties planted in the Yaqui Valley of Mexico rather than global acres planted to CIMMYT varieties. The reason for this is the precision of the data collected within the Yaqui Valley (varieties planted, hectares planted, hectares harvested, hectares planted to CIMMYT varieties, yield, etc.) and the unreliability of the data from outside the Valley.

Since CIMMYT has their principal experiment station in the Yaqui Valley, it has a longstanding working relationship with the local farmers who are willing to exchange

[3] An example of this would be if a specific breeding period focused on one attribute more than others. Breeding for heat stress may have been a more pronounced goal of the breeding program in the last ten years and thus would need to be accounted for.

information regarding their yields, varieties planted, etc. for modern varieties of wheat bred by CIMMYT. CIMMYT varieties are planted outside of the Yaqui Valley in Mexico as well. However the data for other regions of Mexico is much less reliable. Therefore, this study only includes CIMMYT varieties planted in the Yaqui Valley and excludes non-CIMMYT varieties planted within the Yaqui Valley as well as CIMMYT varieties in other regions of Mexico. In that sense, this study provides very a conservative estimate of the effects of the CIMMYT breeding program on Mexican farmers and consumers because of the exclusion of CIMMYT varieties planted in other regions of Mexico.

Since the Yaqui Valley only accounts for approximately 15-20% of the wheat produced in Mexico with approximately 65-80% of these wheat varieties being of CIMMYT germplasm, the effects of the CIMMYT breeding program on increasing Mexican yield (Jt) need to be adjusted (CIMMYT, 2007). Equation (9) is calculated to accurately account for the effects of the CIMMYT breeding program on the Mexican supply curve. The new (Jt') is equal to

$$Jt' = Jt * \Theta t * \psi t \tag{9}$$

where (Jt) is the shift in wheat production associated with the use of CIMMYT varieties in percent increase in yield annually.[4] The variable Θt is the percentage of Mexico's wheat production that takes place in the Yaqui Valley, and ψt is the percentage of the wheat in the Yaqui Valley that is planted to CIMMYT varieties. The modified Jt' represents the Mexican shift in wheat supply based solely on increased yields in the Yaqui Valley attributed to CIMMYT's breeding program. From here forward when the model refers to Mexican producers, losses will be experienced by all producers in Mexico, gains however will only be experienced by those farmers who adopted CIMMYT varieties within the Yaqui Valley. That is, the supply curve represents all of Mexico but positive changes in producer surplus will only be experienced by Mexican producers in the Yaqui Valley who use CIMMYT varieties. Consumer gains/losses will be attributed to all consumers in Mexico.

AN ECONOMIC MODEL OF THE IMPACTS OF CIMMYT WHEAT-BREEDING RESEARCH

Edwards and Freebairn (1984) pioneered an economic model to measure the impact of productivity gains from research into a tradable commodity such as wheat. The model was applied to Australian wool research by Alston and Mullen (1992). This simple two-country model of supply and demand is adopted here to estimate the impact of the research-induced supply shift on producer and consumer surpluses in (A) Mexico, and (B) the rest of the world (ROW, defined as all areas outside of Mexico). Alston et al. (1995) reported explicit formulas for the calculation of changes in economic surplus to producers and consumers in two countries, and their model is modified below to the case of CIMMYT wheat research. The supply (Qsi) and demand (Qdi) curves of wheat are assumed to be linear functions of the world price of wheat (P), as modeled in equations (10) through (14). The subscript i = M

[4] The Nalley et al. (2007) Just and Pope production results indicated that CIMMYT contributed approximately a 0.18% increase in yield annually from 1990-2002 to the Yaqui Valley ($J_t = 0.0018$).

denotes Mexico and i = R for the ROW. (denoted by subscript R) are assumed to be linear functions of the world price of wheat (P), as modeled in equations (10) through (14), where k is the percentage downward shift in supply (k = KP, where K is the percent shift in cost savings, Jt/ε, where ε is the elasticity of supply of wheat). The downward shift in the supply curve is calculated using the release year estimate from the Just and Pope production function, equation (7) from above. The release year coefficient from the Just and Pope model represents the annual genetic gain attributable to the CIMMYT breeding program and thus can be viewed as a shift in the supply curve. Time subscripts have been omitted for notational simplicity.

$$QsM = \alpha M + \beta M(P + k) \tag{10}$$

$$QdM = \gamma M + \delta MP \tag{11}$$

$$QsR = \alpha R + \beta RP \tag{12}$$

$$QdR = \gamma R + \delta RP \tag{13}$$

$$QsM + QsR = QdM + QdR \text{ (market-clearing).} \tag{14}$$

Thus, based upon the above system, we compare the actual state of Mexican and ROW wheat supplies given the existence of CIMMYT germplasm (k > 0) with the counterfactual case in which CIMMYT varieties would be absent (k = 0). To simplify, we assume no transportation costs, resulting in a constant price in both regions, and a system of five equations (10 through 14) to solve for five unknowns: P, QsM, QsR, QdM, and QdR. The solution to this system of equations results in the changes in price and quantities of wheat produced and consumed as a result of the supply shift, as in equations (15) and (16):

$$\Delta P = -k\beta M/(\beta M + \beta R - \delta M - \delta R) < 0 \tag{15}$$

$$\Delta QsM = \beta M(\Delta P + k);\ \Delta QdM = \delta M\Delta P;\ \Delta QsR = \beta R\Delta P;\ \Delta QdR = \delta R\Delta P. \tag{16}$$

The welfare changes for producers and consumers in Mexico and ROW are given in equations (17) through (21), where PS is producer surplus, CS is consumer surplus, and TS is total surplus:

$$\Delta PSM = (k + \Delta P)(QsM + 0.5\Delta QsM) \tag{17}$$

$$\Delta CSM = -\Delta P(QdM + 0.5\Delta QdM) \tag{18}$$

$$\Delta PSR = \Delta P(QsR + 0.5\Delta QsR) \tag{19}$$

$$\Delta CSR = -\Delta P(QdR + 0.5\Delta Qdr) \tag{20}$$

$$\Delta TS = \Delta PSM + \Delta CSM + \Delta PSR + \Delta CSR \tag{21}$$

To solve this model, price and quantity data, together with elasticity estimates of supply and demand and a measure of research-induced productivity change (k), are necessary. Using supply and demand estimates from the 2020 IMPACT model (Rosegrant et al., 1995) a supply elasticity of wheat in Mexico (εM) of 0.17 was used along with a demand elasticity (ηM) of -0.54. Using individual country estimates from the 2020 IMPACT report a weighted (by production and consumption, respectively) global supply and demand estimate for wheat could be calculated (εR =0.13 and ηR = -0.53). Further, given the importance of the magnitude of the wheat supply elasticity in the model, sensitivity analyses were conducted for elasticity estimates ranging from $\varepsilon = 0.075$ to $\varepsilon = 1.0$. The price of wheat (P) is the season average price received by farmers (USDA Agricultural Outlook), deflated by the PCE (US Department of Commerce). The quantity of wheat supplied in Mexico (QsM) was taken from FAOSTAT (2007a), and the Mexican quantity demanded (QdM) is the number of metric tons for food, feed, and seed (FAOSTAT 2007b). Wheat production in ROW (QsR) was found by subtracting Mexican production from the world wheat production reported by FAOSTAT (FAOSTATa,b 2007). The market-clearing equation (14) was then used to calculate ROW demand (QdR).

MODEL RESULTS: RESEARCH-INDUCED CHANGES IN ECONOMIC SURPLUS

The results of the model appear in table 1: Mexican wheat producers gained an average of $1.88 million (2002USD) per year from 1990 to 2002 by growing wheat varieties developed and released by CIMMYT. Not all producers benefited: only those producers who adopted the high-yielding varieties from CIMMYT earned these higher levels of economic surplus. Consumers of wheat in Mexico on average benefited by $0.004 million per year thorough the breeding efforts at CIMMYT from 1990 to 2002. This relatively small benefit resulted from the relatively small research-induced shift in the world supply of wheat: Mexico produced only approximately 0.64% of the world's wheat over this time period (FAO 2007a). An even smaller portion, 0.10%, of the world’s wheat is of CIMMYT germplasm and grown in the Yaqui Valley. This fact allows for large gains for producers who adopted CIMMYT varieties in the Yaqui Valley, with only a negligible decrease in the world price of wheat due to CIMMYT varieties being developed.

Yaqui Valley only accounts for 0.38% of the total global CIMMYT breeding cost.

Wheat producers who resided outside of the Yaqui Valley were made worse off by the decrease in the price of wheat, with an average annual loss of $0.478 million (2002 USD, table 1). Non-Mexican consumers benefited from the research-induced shift in the supply of wheat by an annual average of $0.477 million (2002 USD). The ROW producer losses were approximately equal to the ROW consumer gains. This outcome, together with the relatively large gains to Mexican wheat producers and small Mexican consumer gains, resulted in an annual average change in total economic surplus (ΔTS) of $1.88 million (table 1). These annual benefits were large relative to the annual average costs of the research program of approximately $10.1 million when accounting for the ratio of acres of wheat planted to CIMMYT varieties in the Yaqui Valley to the global CIMMYT acres planted. Since CIMMYT does not disaggregate their breeding budget into regions a simple ratio of average

CIMMYT acres in the Yaqui to global acres planted to CIMMYT crosses is calculated. From 1990 through 2002 there was an average of 56.56 million acres planted to CIMMYT crosses worldwide compared to an average of just 0.216 million acres of CIMMYT germplasm planted in the Yaqui Valley (Lantican et al. 2005). Thus if it is assumed that the breeding costs are constant globally then the Yaqui Valley only accounts for 0.38% of the total global CIMMYT breeding costs.

Table 1. Changes in Economic Surplus from the CIMMYT Wheat Breeding Program, 1990-2002, in 2002 U.S. Dollars

				Mexico		ROW		
Year	Yaqui Acres Planted to CIMMYT Lines	Global Wheat Price (2002 USD/Ton)	k_t[a]	ΔPS_m	ΔCS_m	ΔPS_r	ΔCS_r	ΔTS
1990	290098	220.05	0.90	3,525,331	8,100	-894,055	893,381	3,532,757
1991	199171	138.16	0.35	1,404,043	3,632	-355,866	355,393	1,407,202
1992	214967	152.32	0.45	1,609,335	3,535	-408,690	407,816	1,611,996
1993	214825	153.23	0.47	1,945,337	4,471	-493,670	492,852	1,948,990
1994	188071	138.51	0.32	1,334,782	3,371	-338,561	337,877	1,337,468
1995	191693	157.36	0.41	1,421,093	3,371	-360,897	360,007	1,423,416
1996	156347	236.77	0.61	2,060,935	4,728	-523,652	521,965	2,063,976
1997	198826	205.46	0.68	2,467,597	5,160	-626,920	625,524	2,471,361
1998	207845	156.64	0.57	1,848,034	4,245	-469,719	468,054	1,850,613
1999	217679	128.07	0.58	1,751,108	4,181	-445,229	443,351	1,753,411
2000	301399	113.46	0.59	2,074,135	5,105	-527048	525,098	2,077,289
2001	190861	118.36	0.41	1,329,925	3,336	-337,998	336,549	1,331,812
2002	211722	128.60	0.53	1,723,423	4,413	-437,994	436,072	1,725,913
Mean	214116	157.46	0.53	1,884,237	4,434	-478,484	477,226	1,887,400

[a] $k_t = K_tP_t$, where $K_t = J_t'/\varepsilon$ and P_t is the wheat price.

The final step in the evaluation of the impacts of the CIMMYT wheat breeding program was to calculate the rate of return to the public investment in the genetic improvement of wheat varieties. Proper measurement of the rate of return requires consideration of the timing of varietal development and the discounting procedure. Input from CIMMYT agronomists led to the assumption that 10 years are required to develop a variety from the initial variety cross to the release date (Ammar 2006).[5] Because of the nature of the data set, the economic benefits of CIMMYT semi-dwarf varieties began in 1990. To capture the lag between initially crossing a variety and releasing it, costs from the period of 1981 to 2002 were included in the analysis (table 2).

[5] Interviewed CIMMYT breeders stated that on average there is a 5-year breeding and testing period at CIMMYT followed by a 3 to 4 year testing period at experiment stations within Mexico, such as the Yaqui Valley station. The last step is a 2 year seed production stage before its release.

Table 2. Cost and Benefits of the CIMMYT Wheat Breeding Program, 1981-2011

Year	Estimated Costs 2002 USD (Global)[a]	Estimated Costs 2002 USD (Yaqui)[b]	Benefits (ΔTS) 2002 USD[c]
1981	13,400,000	49,911	0
1982	14,200,000	62,791	0
1983	14,500,000	51,482	0
1984	14,900,000	45,978	0
1985	14,600,000	54,333	0
1986	14,400,000	67,186	0
1987	13,700,000	42,377	0
1988	15,000,000	59,226	0
1989	13,300,000	60,690	0
1990	13,100,000	62,264	3,532,757
1991	13,200,000	43,451	1,407,202
1992	13,500,000	48,385	1,611,996
1993	13,300,000	48,060	1,948,990
1994	10,900,000	34,791	1,337,468
1995	9,500,000	31,186	1,423,416
1996	9,900,000	26,749	2,063,976
1997	9,600,000	35,433	2,471,361
1998	9,600,000	37,407	1,850,613
1999	10,100,000	41,629	1,753,411
2000	7,000,000	40,352	2,077,289
2001	7,000,000	25,814	1,331,812
2002	6,000,000	23,053	1,725,913
2003	0	0	1,573,027
2004	0	0	1,398,246
2005	0	0	1,223,465
2006	0	0	1,048,685
2007	0	0	873,904
2008	0	0	699,123
2009	0	0	524,342
2010	0	0	349,562
2011	0	0	174,781

[a]Costs for the period 1981-2002 are the deflated annual program costs of the CIMMYT breeding program.

[b]Since CIMMYT only releases global breeding costs a ratio was used to determine the portion of the global cost associated with the Yaqui Valley. Costs attributed to the Yaqui are calculated as $\text{Global Cost} * \left(\frac{\text{CIMMYT acres in Yaqui}}{\text{Global CIMMYT acres}} \right)$ where global CIMMYT acres are the number of acres in a respective year planted to CIMMYT crosses globally.

[c]Benefits for the period 1990-2002 are the deflated total economic surplus derived from the CIMMYT wheat breeding program (in table 1). Program benefits after 2002 are the 5-year average benefit level from 1998 to 2002 ($1.75 million) assumed to decrease at 10 % per year, until all benefits are depleted in year 2012

CIMMYT breeds for 12 specific "mega-environments" throughout the world, but does not disaggregate their breeding budget between environments.[6] Mega-environment 1, of which the Yaqui Valley is a part, is the largest, with 18.2% of the world's wheat production occurring in this mega-environment (Lantican et al. 2005). Since CIMMYT does not disaggregate breeding costs into specific mega-environments, the following calculations attribute all breeding costs to mega-environment 1. The resulting benefit- cost ratios will be conservative since the costs have been overstated.

The economic benefits (ΔTS) reported in table 1 were used for the period 1990 to 2002. After 2002, the 5-year average benefit level from 1998 to 2002 ($1.75 million) was assumed to decrease at 10% per year, until all research program benefits are depleted in year 2011. Cost and benefit data are reported in table.

The benefit-cost ratio (BCR) is calculated as a measure of gross research benefits:

(22) $$\text{BCR}=\frac{\sum_t \frac{\text{B}_t}{(1+r)^t}}{\sum_t \frac{\text{C}_t}{(1+r)^t}}$$

where Bt is the total economic surplus in year t (ΔTS from table 1), Ct represents annual program costs just in the Yaqui valley, and r is the assumed rate of discount. The BCR for CIMMYT wheat varieties, assuming a 10% rate of discount, equals 14.97 (table 4): for each dollar of public funds invested in wheat breeding research, nearly 15 dollars of benefits result, with over 99% (1.88/1.89) of the benefit received by Mexican wheat producers in the Yaqui valley who used CIMMYT varieties.

The Net Present Value (NPV) of the program may also be estimated using equation (23):

(23) NPV = Σt[(Bt -Ct)/(1+r)t].

The NPV of the program for the period 1981 to 2011, with an assumed discount rate of 10% equals $6.12 million 2002 USD (table 4).

A third measure of economic performance is the Internal Rate of Return (IRR), computed as the discount rate that results in a value of zero for the NPV as in equation (24):

(24) 0 = Σt[(Bt -Ct)/(1+IRR)t].

The IRR for the wheat breeding program equaled 51.4% (table 4). The BCR, NPV, and IRR provide evidence that the economic rate of return to CIMMYT wheat breeding is high, although assessing these measures further is difficult without comparable values for other public investments (the opportunity cost of funds).

[6] Mega-environment 1 is classified as low latitude (35^o N-35^oS), irrigated land, temperate climate, with the major constraints being rust and lodging. It consists of 35% of the wheat production in South and East Asia, 33% in West Asia and North Africa, 28% in South and East Asia, and 7% in Latin America. It accounts for 42.9% of the worlds total durum wheat acres and 16.5% of its total bread wheat acres (Lantican et al. 2005)

SENSITIVITY ANALYSIS

The results of the two-region wheat model reported here are contingent upon numerous assumptions.[7] To determine how robust the model results are to changes in elasticity parameters, a sensitivity analysis was conducted by altering the assumed values of the four elasticities: εM, εR, ηM, ηR. Table 3 reports the model results for a range of elasticity values for the average annual changes in producer, consumer, and total economic surpluses for the period 1990 to 2002. The model was estimated for both relatively inelastic supply (ε= 0.1) and relatively elastic supply (ε= 0.5) for both Mexico and the ROW.

Table 3. Sensitivity Analysis of Elasticity Assumptions in World Wheat Model, 1990 to 2002

Mexico		ROW		Mexico		ROW		
ε_M	η_M	ε_R	η_R	ΔPS_m	ΔCS_m	ΔPS_R	ΔCS_R	ΔTS
0.17	-0.54	0.12	-0.53	1,884,237	4,434	-478,484	477,226	1,887,400
0.1[a]	-0.54	0.12	-0.53	3,205,414	4,437	-478,815	477,555	3,208,580
0.5[a]	-0.54	0.12	-0.53	638,564	4,420	-476,933	475,678	641,717
0.17	-0.1[a]	0.12	-0.53	1,884,217	4,462	-481,403	480,137	1,887,400
0.17	-1.0[a]	0.12	-0.53	1,884,257	4,406	-475,471	474,221	1,887,400
0.17	-0.54	0.1[a]	-0.53	1,884,090	4,640	-500,688	499,371	1,887,400
0.17	-0.54	0.5[a]	-0.53	1,885,361	2,857	-308,306	307,495	1,887,400
0.17	-0.54	0.12	-0.1[a]	1,877,992	13,189	-1,423,413	1,419,670	1,887,402
0.17	-0.54	0.12	-1.0[a]	1,885,510	2,648	-285,771	285,019	1,887,400

[a] Elasticity values designated with a superscript 'a' differ from the baseline elasticities in the first row

Changes in the value of the Mexican supply elasticity (εM) resulted in large changes in Mexican producer surplus from higher-yielding wheat varieties: an inelastic Mexican wheat supply (εM = 0.1) resulted in an increase in the annual average producer surplus from $1.884 to $3.205 million (2002 USD). Conversely, when the elasticity of Mexican wheat supply was relatively elastic (εM = 0.5), the average annual change in producer surplus decreased from

[7] Selection of the correct functional form of supply and demand curves in welfare analyses has received a great deal of attention by previous researchers. Alston, Norton, and Pardey (1995) summarized this extensive discussion: "It turns out, empirically, that measures of total research benefits and their distribution between producers and consumers are quite insensitive to choices of functional form" (page 63). After summarizing the extensive debate over functional form and the nature of the supply shift (parallel vs. pivotal), Alston, Norton, and Pardey concluded, "Our preference -- in the absence of the information required to choose a particular type of shift -- is to follow Rose's (1980) suggestion and employ a parallel shift… Under this assumption, the functional forms of supply or demand are unimportant" (page 64). Following this line of reasoning, this study assumes a parallel supply shift and linear supply and demand curves.

$1.884 to $0.638 million. These large changes in producer surplus arose because only 0.1% of world wheat production occurred in Mexico's Yaqui Valley. If Mexican wheat supply is inelastic, an increase in Mexican wheat production results in large cost savings for Mexican wheat producers, accompanied by a relatively small decrease in the world price of wheat, because the Yaqui Valley is such a small part of the world wheat market. Likewise, if Mexican wheat supply is relatively elastic, then supply increases resulting from enhanced wheat varieties require larger price decreases for the market to clear, causing lower levels of surplus for Mexican wheat producers.

Changes in the value of the ROW supply elasticity only marginally alter Mexican producer surplus. Mexican consumers, ROW producers, and ROW consumers are affected: a larger elasticity of wheat supply outside of Mexico results in smaller losses for ROW producers and smaller gains for consumers in both Mexico and the ROW.

Demand elasticities also were altered over a broad range of values, from relatively inelastic ($\eta = -0.1$) to unitary elastic ($\eta = -1.0$). Because Mexican wheat consumers represent only 0.93% of the world wheat market, the elasticity of Mexican wheat demand (ηM) ηad an insignificant impact on the model results (table 3). However, the elasticity of demand in the ROW (ηR) did affect ROW producers and all wheat consumers. A relatively elastic ROW demand decreased consumer surplus gains in both Mexico and the ROW but also decreased losses to ROW producers from technological change in Mexico. When world demand is elastic, a supply shift causes a large increase in the quantity of wheat, accompanied by a small decrease in price.

The changes in annual averages of total economic surplus ($\Delta T\Sigma$) in table 3 reveal that the model results were affected most strongly by Mexico's supply elasticity (εM). Total economic surplus was not affected by changes in the other supply and demand elasticity values. As a result, further calculations were made of the rate of return to the Mexican wheat breeding program under a range of Mexican supply elasticities (εM) and discount rate (r) values (table 4).

The BCRs reported in table 4 demonstrate a range of results under differing assumptions for Mexico's supply elasticity (εM) and discount rate (r). The baseline BCR is 14.97 ($r = 0.10$, $\varepsilon M = 0.17$). Smaller supply elasticities and lower discount rates increase the total benefits to society resulting from higher-yielding CIMMYT wheat varieties. When varying the discount rate from 0.05 to 0.20 and maintaining the baseline supply elasticity the BCR was 21.95 and 7.22, respectively. Similarly, the NPV is centered around 6.122 million 2002 USD ($r = 0.10$, $\varepsilon M = 0.17$) but ranges from $0.532 ($r = 0.20$, $\varepsilon M = 0.4$) to $30.690 ($r = 0.05$, $\varepsilon M = 0.075$) million (2002 USD). The IRR ranged from 0.369 ($\varepsilon M = 0.4$) to 0.667 ($\varepsilon M = 0.075$), indicating high social returns to investments in wheat breeding research in CIMMYT.

The results of the sensitivity analysis reported in table 3 are wide-ranging, because the parameter values for the supply elasticities and the discount rate were selected purposefully to cover a broad range of possible values. The baseline parameter values represent the most likely scenario. The major conclusion from the model that the economic returns to the CIMMYT wheat-breeding program are high, with a baseline result on the order of $15 in additional surplus generated for every $1 of program cost. That the benefits exceed the cost is verified across the entire range of elasticity and discount parameters selected in our analysis

Table 4. Sensitivity Analysis of the Rate of Return to the CIMMYT Wheat Breeding Program.

BENEFIT-COST RATIO (BCR)[a]

	Discount Rate			
Elasticity of Mexican Wheat Supply (ε_M)	0.05	0.10	0.15	0.20
0.075	49.75	33.95	23.43	16.37
0.1	37.31	25.46	17.57	12.28
0.17	21.95	14.97[b]	10.34	7.22
0.2	18.66	12.73	8.79	6.14
0.4	9.33	6.37	4.39	3.07

NET PRESENT VALUE (NPV) in 2002 USD [c]

	Discount Rate			
Elasticity of Mexican Wheat Supply (ε_M)	0.05	0.10	0.15	0.20
0.075	30,690,507	14,433,194	7,332,595	3,953,569
0.1	22,860,499	10,715,394	5,417,707	2,900,877
0.17	13,188,136	6,122,818[b]	3,052,258	1,600,492
0.2	11,115,486	5,138,694	2,545,376	1,321,838
0.4	5,242,980	2,350,344	1,109,211	532,319

INTERNAL RATE OF RETURN (IRR) [d]

Elasticity of Mexican Wheat Supply (ε_M)	IRR
0.075	0.667
0.1	0.612
0.17	0.514[b]
0.2	0.486
0.4	0.369

[a]The calculation for the Benefit-Cost Ratio (BCR) is from equation 22.
[b]The values designated by the superscript "b" are the baseline model values.
[c]The calculation for the Net Present Value (NPV) is from equation 23.
[d]The calculation for the Internal Rate of Return (IRR) is from equation 24.

(tables 4 and 5). Although the rate of return varied with the selected elasticity of supply and the discount rate, in all cases the benefits exceeded the costs–with a low estimate of an order of 3:1 and a high estimate on the order of 50:1.

CONCLUSION

Results of the two-region economic model of the CIMMYT research-induced wheat supply increase in Mexico provide empirical evidence that the wheat producers who adopt the modern CIMMYT varieties are the major beneficiaries of the technological advance. Mexican consumers are made better off, but by only a small fraction of the value of wheat purchased. A transfer of economic surplus from non-Mexican producers to ROW consumers of approximately $0.478 million (2002 USD) occurs annually because of the decrease in the world price of wheat induced by the enhanced yields of CIMMYT wheat varieties in Mexico's Yaqui Valley.

CIMMYT, a nonprofit organization, competes with other nonprofits for limited public funds. Given relatively large increases in CIMMYT maize yields, CIMMYT cut its wheat breeding program budget during the period 1990-2002. Continued public funding for wheat breeding research depends on how well the program is serving the public. A solid measure of the effectiveness of a breeding program is a benefit-cost analysis. This research found that during the period 1990-2002, CIMMYT generated a benefit-cost ratio of 15:1, implying that for each dollar of public funds invested that 15 dollars of benefits resulted. This corresponds to an internal rate of return of some 51% over the entire period.

One implication for wheat breeders is that any decrease in the long development time (10 years) of a variety would result in large economic benefits to society. An example of this is greenhouse breeding, which allows for two generations of winter wheat to be grown in one year. A major implication of this research is that more resources could be allocated advantageously to the wheat breeding program at CIMMYT. While resources committed to the CIMMYT wheat breeding program have declined in real terms in recent years, the information presented here provides compelling evidence that there are large returns to the wheat improvement research conducted at CIMMYT.

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COMPETITION BETWEEN CHINA AND THE UNITED STATES IN THE KOREAN FOOD MARKET

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ABSTRACT

Korea, a large net-food importing country, is rapidly opening its doors to agricultural imports. In this study, we investigate the nature and extent of competition between two major exporters, China and the United States, in the Korean food market. We first employ the un-centered correlation distance approach to investigate the similarities in the export structures of major exporters to the Korean market. Results show that the similar export structures of China and the United States have made the latter vulnerable to competition. Secondly, the concept of competitive threat is used to determine which country faces a possible decline in food exports to Korea. Here, we show that China poses a threat to the United States in virtually every agricultural product exported to Korea. It appears that economic integration, especially that of China into world markets, has magnified agricultural trade gains from geographical and cultural proximity.

Key words: Agricultural trade, Korea, Trade competition
JEL codes: F14, Q17

INTRODUCTION

Korea is a large importer of agricultural goods in the global economy and a significant market to numerous agricultural exporters. The Korean market for foreign agricultural goods is considered to be a growing opportunity, with the current trend towards globalization. Until the early 1990s, the United States was the largest exporter of agricultural goods to Korea. In 1989 alone, U.S agricultural products accounted for about 60 percent of the Korean food imports. However, the emergence of China's economy in the last two decades has significantly altered the Korean-US food trade as well as Korea's trade with other major food exporters. Although Korea imported agricultural products from China prior to 1990, the

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limited volume and infrequent trade did not have much impact on the Korean food market. Following the Amity Treaty of 1992, China's agricultural products began to have a significant impact on the Korean food market. In addition, the obligations under the Uruguay Round and China's accession into the World Trade Organization (WTO) have accelerated the inflow of the latter's agricultural products into the Korean food market. Other than the obvious price advantage over other exporters, China possesses similar agricultural varieties and breeds that easily fulfill the needs of the Korean consumer, and also is geographically adjacent to the Korean peninsula, saving transport costs on bulky food products. The recent increase in China's food exports to Korea has been a serious concern to major agricultural exporters, especially the United States (Elwell, Labonte, and Morrison 2007; Im 2002).

The objective of this article to investigate the nature and extent of competition between China and the United States in the Korean food market. Previous literature has focused on the competitive threat of China in the low-end manufacturing sector, and more recently in the cutting-edge technology sector (Castro, Olarreaga, and Saslavsky 2006; Lall and Albaladejo 2004 and 2002; Chae and Han 2002; Carolan, Singh, and Talati 1998). However, few studies directly address China's role on global food markets, where Korea is a major importer. In particular, we examine China's impact on the Korean food market, which will help understand the changing relationship between Korea and its trade partners, especially the United States (Moreira 2007; Wall 2006; Li 2002). In the empirical trade-literature context, this study will identify the nature of trade substitution among major trading partners, with insights on factors contributing to competitiveness.

THE UNITED STATES AND CHINA IN THE KOREAN FOOD MARKET

Table 1a and 1b show Korean imports, in current and constant (2005) dollar, of agricultural products which are under the coverage of the WTO's Agricultural negotiations. Throughout the study, these 33 items selected under the two-digit HS code will be our analytical categories. Moreover, our analysis is based on market shares using current dollar imports since deflating appears not to affect trends and results.[1] Several agricultural items previously included in non-agricultural categories were discerned and used in our analysis. [2]Although we have data on these products at the four-digit HS code, we have presented data on two-digit HS products due to space limitations.

As can be seen from table 1, Korean agricultural imports are increasing over the past 15 years with the exception of cotton (HS52). The general downward trend between 1994 and 2001 reflects the effects of the financial crisis in the East Asian region during the late 1990s. Cereal (HS10) is the largest imported item in the Korean food market, followed by Meat and Edible Offal (HS02) in the distant second. Organic chemicals (HS29), i.e., acyclic alcohols and their derivatives, and Oilseeds (HS12) are respectively the third and fourth largest import

[1] For instance, acyclic alcohols and their derivatives, which fall under the four-digit code HS2905, was previously listed as non-agricultural product. In our study, HS20905 is the sole representative of the organic chemicals category (HS29), i.e., the value for category HS29 is, in fact, the value for HS2905.

[2] For instance, acyclic alcohols and their derivatives, which fall under the four-digit code HS2905, was previously listed as non-agricultural product. In our study, HS20905 is the sole representative of the organic chemicals category (HS29), i.e., the value for category HS29 is, in fact, the value for HS2905

items in terms of value during 2002-2005. The growth of total (real) imports in table 1b points to the increasing demand for foreign foods in the domestic Korean market.

Table 1a. Korean Agricultural Import Values (in millions of US Dollars)

HS Code	1990-1993	1994-1997	1998-2001	2002-2005
01 - Live animals	77.90	143.28	103.83	153.09
02 - Meat and edible meat offal	2,050.44	3,198.49	4,221.43	5,694.75
04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	185.79	559.52	683.56	900.58
05 - Products of animal origin, not elsewhere specified or included	627.97	606.73	466.68	429.17
06 - Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	97.30	169.49	162.21	191.07
07 - Edible vegetables and certain roots and tubers	416.24	562.04	655.68	991.20
08 - Edible fruit and nuts; peel of citrus fruit or melons	603.25	558.73	876.55	1,603.61
09 - Coffee, tea, maté and spices	407.94	770.18	731.31	577.21
10 - Cereal	5,978.23	6,920.46	7,378.61	7,943.33
11 - Products of the milling industry; malt; starches; inulin; wheat gluten	131.29	234.92	290.55	419.70
12 - Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder	1,937.04	2,722.84	3,003.09	3,296.61
13 - Lac; gums, resins and other vegetable saps and extracts	179.94	200.24	231.32	320.31
14 - Vegetable plaiting materials; vegetable products not elsewhere specified or included	37.19	58.03	67.21	58.41
15 - Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	952.88	1,469.56	1,510.33	1,981.30
16 - Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates	81.44	105.22	140.29	210.99
17 - Sugars and sugar confectionery	1,836.12	2,052.73	1,934.18	1,993.70
18 - Cocoa and cocoa preparations	314.71	360.11	378.68	596.50
19 - Preparations of cereals, flour, starch or milk; pastrycooks' products	187.81	308.73	433.57	775.73
20 - Preparations of vegetables, fruit, nuts or other parts of plants	815.38	1,109.52	1,148.22	1,582.77
21 - Miscellaneous edible preparations	565.09	878.82	1,202.55	1,948.25
22 - Beverages, spirits and vinegar	403.67	945.62	1,203.09	1,883.58
23 - Residues and waste from the food industries; prepared animal fodder	1,501.11	2,160.47	2,283.96	3,101.63

Table 1a. Korean Agricultural Import Values (in millions of US Dollars) (Continued)

HS Code	1990-1993	1994-1997	1998-2001	2002-2005
24 - Tobacco and manufactured tobacco substitutes	813.14	1,382.56	1,080.49	1,026.69
29 - Organic chemicals	1,239.20	2,518.70	2,554.83	4,258.42
33 - Essential oils and resinoids; perfumery, cosmetic or toilet preparations	63.03	68.16	51.08	60.29
35 - Albuminoidal substances; modified starches; glues; enzymes	369.94	470.62	454.61	565.07
38 - Miscellaneous chemical products	169.41	208.14	217.56	250.90
40 - Rubber and articles thereof	2,208.75	2,931.16	1,983.91	2,873.01
43 - Furskins and artificial fur; manufactures thereof	466.17	958.64	294.33	287.46
50 - Silk	395.94	312.32	171.16	124.24
51 - Wool, fine or coarse animal hair; horsehair yarn and woven fabric	872.45	803.53	441.51	336.07
52 - Cotton	2,583.54	2,385.25	1,959.36	1,588.21
53 - Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn	18.90	143.28	14.20	8.00
Total	**26,005.67**	**35,771.11**	**36,370.58**	**46,443.62**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE)

Table 1b. Korean Agricultural Import Values (in millions of 2005 US Dollars)

HS Code	1990-1993	1994-1997	1998-2001	2002-2005
01 - Live animals	77.90	143.28	103.83	153.09
02 - Meat and edible meat offal	2,050.44	3,198.49	4,221.43	5,694.75
04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	185.79	559.52	683.56	900.58
05 - Products of animal origin, not elsewhere specified or included	627.97	606.73	466.68	429.17
06 - Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	97.30	169.49	162.21	191.07
07 - Edible vegetables and certain roots and tubers	416.24	562.04	655.68	991.20
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13 - Lac; gums, resins and other vegetable saps and extracts	179.94	200.24	231.32	320.31
14 - Vegetable plaiting materials; vegetable products not elsewhere specified or included	37.19	58.03	67.21	58.41
15 - Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	952.88	1,469.56	1,510.33	1,981.30
16 - Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates	81.44	105.22	140.29	210.99
17 - Sugars and sugar confectionery	1,836.12	2,052.73	1,934.18	1,993.70
18 - Cocoa and cocoa preparations	314.71	360.11	378.68	596.50
19 - Preparations of cereals, flour, starch or milk; pastrycooks' products	187.81	308.73	433.57	775.73
20 - Preparations of vegetables, fruit, nuts or other parts of plants	815.38	1,109.52	1,148.22	1,582.77
21 - Miscellaneous edible preparations	565.09	878.82	1,202.55	1,948.25
22 - Beverages, spirits and vinegar	403.67	945.62	1,203.09	1,883.58
23 - Residues and waste from the food industries; prepared animal fodder	1,501.11	2,160.47	2,283.96	3,101.63
24 - Tobacco and manufactured tobacco substitutes	813.14	1,382.56	1,080.49	1,026.69
29 - Organic chemicals	1,239.20	2,518.70	2,554.83	4,258.42
33 - Essential oils and resinoids; perfumery, cosmetic or toilet preparations	63.03	68.16	51.08	60.29
35 - Albuminoidal substances; modified starches; glues; enzymes	369.94	470.62	454.61	565.07
38 - Miscellaneous chemical products	169.41	208.14	217.56	250.90
40 - Rubber and articles thereof	2,208.75	2,931.16	1,983.91	2,873.01
43 - Furskins and artificial fur; manufactures thereof	466.17	958.64	294.33	287.46
50 - Silk	395.94	312.32	171.16	124.24
51 - Wool, fine or coarse animal hair; horsehair yarn and woven fabric	872.45	803.53	441.51	336.07
52 - Cotton	2,583.54	2,385.25	1,959.36	1,588.21
53 - Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn	18.90	143.28	14.20	8.00
Total	**26,005.67**	**35,771.11**	**36,370.58**	**46,443.62**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE) Price deflator from the Ministry for Food, Agriculture, Forestry and Fisheries, Korea.

Table 2. China's Agricultural Export to World (in millions of US Dollars)

HS Code	1992-1993	1994-1997	1998-2001	2001-2005
01	931.873	1933.063	1555.465	1329.472
02	718.957	3711.471	3125.052	2760.058
04	302.161	679.111	718.544	917.057
05	768.758	2593.419	2680.171	3377.893
06	34.173	113.073	127.224	233.795
07	2186.917	6355.517	6291.944	9652.193
08	627.755	1819.296	1712.207	3290.058
09	927.609	1964.655	2057.161	2967.365
10	2958.228	2971.803	5306.676	6391.689
11	110.922	585.151	385.756	630.219
12	1646.891	4375.109	3347.372	4643.811
13	61.998	189.777	214.240	336.243
14	96.266	216.148	170.445	182.659
15	342.929	2018.533	713.080	676.844
16	502.481	1256.594	1773.734	3537.268
17	1325.830	1095.127	651.321	1093.084
18	81.097	182.040	139.776	270.098
19	249.300	882.643	1325.217	2393.448
20	1371.159	3991.030	4967.943	9597.703
21	233.344	930.920	1424.236	2334.822
22	628.047	1630.227	1967.447	2681.000
23	935.811	1410.910	951.235	1771.475
24	1081.608	3318.656	1602.398	1976.570
29	30.267	195.431	191.422	635.133
33	149.585	343.427	253.496	292.792
35	19.429	90.816	148.557	653.748
38	9.042	56.440	167.323	280.674
40	37.624	210.750	197.351	476.774
43	19.281	26.082	22.079	26.277
50	569.258	1382.368	1144.077	1018.275
51	2.122	6.876	6.476	13.700
51	221.326	332.002	80.719	160.490
52	440.468	228.589	733.662	333.469
53	11.276	21.188	19.267	10.931
Total	**19633.79**	**47118.24**	**46173.07**	**66947.09**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE)

Table 2 shows the rapidly increasing trade value of China's agricultural exports to the world. Exponential growth is seen in the last 5 years, especially in HS codes 07 (Edible vegetables), 10 (Cereal) and 12 (Oil seed), which coincidentally are the top 3 items imported by Korea. Table 3 shows the growth of China's exports to the Korean market. They show that China's export growth to Korea in several products match the latter's overall import growth.

Table 3. China's Agricultural Exports to Korea (in millions of US Dollars)

HS Code	1992-1993	1994-1997	1998-2001	2002-2005
01	1.18	3.77	0.96	1.86
02	6.58	69.60	21.28	21.54
04	8.24	10.29	7.89	16.23
05	16.53	76.61	82.44	107.53
06	14.10	2.92	4.41	18.25
07	71.55	291.77	317.94	674.97
08	83.39	47.50	33.20	93.67
09	21.37	63.96	67.99	137.20
10	925.70	907.67	1513.10	2733.11
11	924.52	51.51	59.77	111.01
12	115.12	453.68	359.04	546.70
13	108.82	10.18	13.18	23.48
14	9.31	18.66	5.09	7.55
15	14.87	22.63	21.30	69.93
16	9.68	10.62	8.12	71.44
17	4.06	2.94	18.47	55.81
18	2.11	0.42	3.22	21.23
19	22.25	80.48	114.88	235.44
20	44.56	137.99	155.65	368.12
21	28.10	61.57	130.45	232.96
22	34.04	60.62	63.58	86.22
23	170.63	369.41	202.37	285.01
24	154.58	282.80	19.67	57.09
29	16.90	62.59	19.98	70.95
33	4.25	0.31	0.45	1.75
35	0.16	5.25	8.03	34.33
38	0.32	1.47	9.47	20.53
40	14.75	14.63	21.57	45.45
43	15.11	0.67	0.25	0.06
50	19.95	115.51	103.22	81.86
51	31.20	34.90	13.89	17.79
52	56.77	9.90	217.50	66.90
53	45.10	0.96	0.34	0.54
Total	**2995.8**	**3283.79**	**3618.7**	**6316.51**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE)

For instance, Cereal (HS10) is not only the largest, but also the fastest growing product imported by Korea. Some of the reasons cited for this match in growth include low costs, similar breeds of crop, and geographical intimacy (McKibbin and Woo 2003). The largest export of China to Korea and the second-most imported good in the Korean market, vegetables, has shown steady growth after a major decline during 1994-1997. Similarly, Oilseeds imports from China are growing at a rate similar to overall Korean imports of that category.

Table 4. U.S. Agricultural Exports to the World (in millions of USD)

HS Code	1991-1993	1994-1997	1998-2001	2001-2005
01	1852.64	2364.01	3103.03	2623.83
02	11463.13	23888.85	25709.84	23514.28
04	1771.31	2716.16	3030.76	3959.62
05	955.75	1556.45	1773.58	2460.56
06	684.03	1006.85	1176.46	1210.51
07	4320.67	6831.06	7425.11	8557.51
08	9451.04	15840.56	15499.90	20758.80
09	648.42	1634.42	1671.00	1687.25
10	32138.09	53366.55	39938.16	45425.06
11	1308.09	2021.33	1944.74	2728.75
12	16083.75	29904.82	26066.15	34047.90
13	529.62	760.19	1001.07	1258.69
14	64.00	136.95	116.00	111.26
15	4131.12	8335.14	7535.59	7804.88
16	812.63	1800.42	2067.71	2353.41
17	1406.84	2377.65	2681.56	2899.23
18	1061.19	1817.41	2275.89	2992.65
19	2460.20	4434.16	5594.15	6782.10
20	4786.70	8059.32	8752.91	8851.79
21	4180.00	8540.64	10244.48	13237.93
22	3051.94	6801.65	6869.59	8324.47
23	9948.72	15282.77	15086.32	14429.77
24	17788.66	26659.96	20817.07	10934.87
29	1884.64	3750.10	3601.45	5614.94
33	586.88	1050.81	1166.57	1286.83
35	833.72	2067.09	3077.45	3037.02
38	341.35	837.68	989.64	1119.59
40	2850.91	4945.01	5188.07	7151.48
43	307.26	620.56	584.05	642.46
50	3.65	3.69	7.25	10.29
51	67.92	146.74	95.72	132.85
52	6153.16	11950.58	7795.47	13880.16
53	4.71	3.83	3.09	7.21
Total	**143932.7**	**251513.4**	**232889.8**	**259837.9**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE)

U.S. agricultural exports to the world for the 33 products are shown in table 4. For the United States, the three largest global exports are cereal, meat and oilseeds as in the case of China. Although the growth rate of agricultural exports is not as dramatic as that of China, the total value for U.S. agricultural exports is more than twice of that of China. However, table 5 also shows that the trend of U.S. agricultural exports to the Korean market is the opposite of

China. In the case of cereals, China has witnessed exponential growth while U.S. exports to the Korean market have declined. Note also that China has been successful with Cereal exports not only in the Korean market, but also in the world market since 1994. The simultaneous surge in China's exports and decline in U.S. exports imply that the competition between the two countries has been favorable to the former in the Korean market.

Table 5. U.S. Agricultural Exports to Korea (in millions of US Dollars)

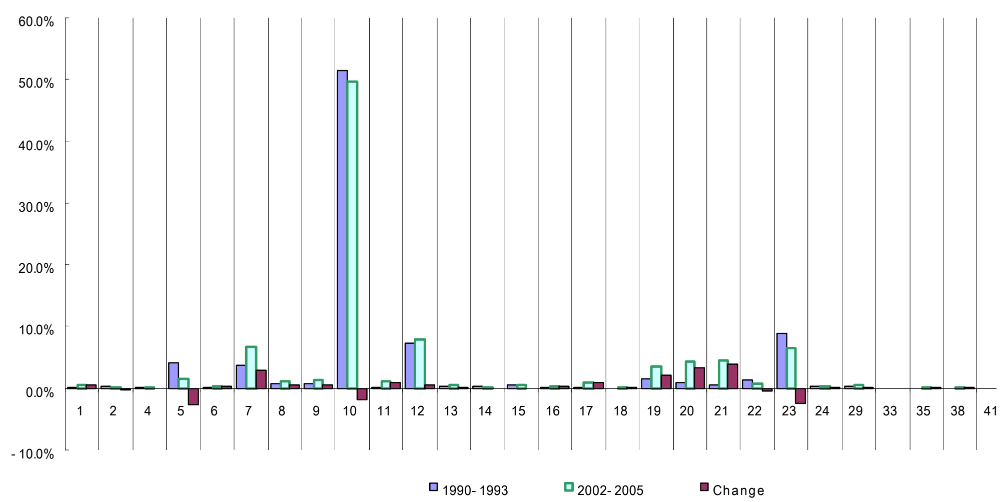
HS Code	1991-1993	1994-1997	1998-2001	2002-2005
1	16.04	31.30	23.88	30.21
2	622.57	1324.84	1724.50	1941.23
4	19.07	85.05	85.24	137.22
5	38.68	43.62	36.14	56.99
6	0.70	1.15	1.25	3.47
7	13.56	55.13	28.41	84.50
8	72.34	184.41	228.26	586.52
9	12.62	34.62	21.12	25.30
10	1113.78	4153.16	2340.98	1805.77
11	6.44	19.30	30.82	12.74
12	759.26	1452.60	1210.06	1454.71
13	43.99	31.29	30.82	66.11
14	0.40	2.27	0.86	0.94
15	139.58	287.87	310.35	165.58
16	28.26	49.40	43.56	67.45
17	39.52	79.32	82.73	71.62
18	26.86	60.85	48.14	128.14
19	28.08	63.52	92.83	97.95
20	194.61	399.47	387.97	394.65
21	144.94	294.45	341.53	565.56
22	20.90	100.45	69.75	119.94
23	100.65	107.53	214.52	185.89
24	350.84	719.17	460.71	192.31
29	108.68	404.00	380.72	565.91
33	14.85	28.40	13.29	19.39
35	38.26	76.69	58.62	52.42
38	13.65	14.75	17.72	16.40
40	77.09	139.35	97.42	145.68
43	64.12	194.76	87.48	97.17
50	0.40	0.03	0.01	0.29
51	0.29	4.39	3.90	1.01
52	1003.42	1160.34	593.85	567.56
53	0.18	0.04	0.10	0.22
Total	**5114.63**	**11603.52**	**9067.54**	**9660.85**

Source: United Nations Statistics Division, Commodity Trade Database (COMTRADE)

SIMILARITIES OF EXPORT STRUCTURE BETWEEN CHINA AND THE UNITED STATES

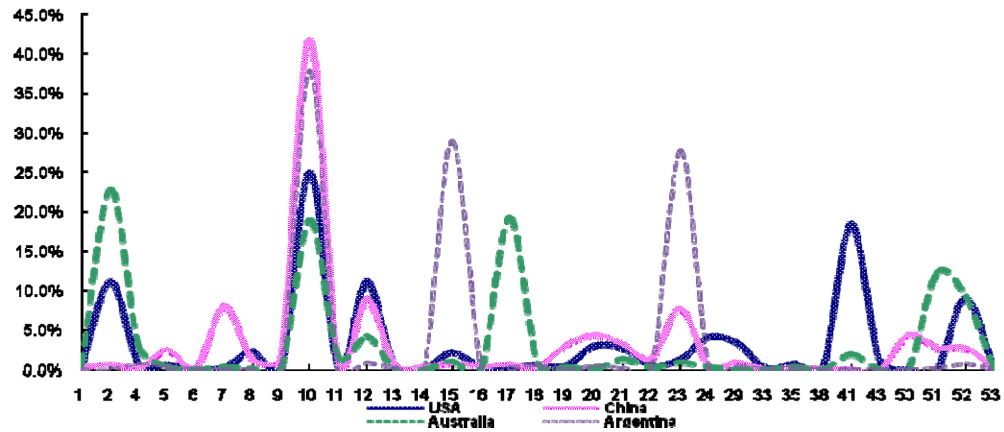
Few studies have addressed how to measure the degree of competition between two exporters in a third-country market (Lall and Albaladejo 2004). The more similar the exporting structures of the two countries, the stronger is their likely competition in the third market. In the following, we first graphically compare export structural similarities among China, the United States and other countries serving the Korean market to better understand the nature of competition in the latter. Second, a quantitative method is used to compare the similarities of the export structure between China and other significant players in the Korean market with emphasis on the United States.

The structure of China's agricultural exports to Korea during 1990-2005 is first shown in Figure 1. Value of China's Cereal exports (HS10) has steadily increased and remained its largest agricultural product exported to Korea as in Table 3. However, Cereal's relative share of exports has been falling as in the case of products of animal origin (HS05), residues/wastes of food industry (HS23) and other processed goods (HS50, HS51, HS52). In contrast, export shares in value terms have increased for HS19, which contains cereal, flour, starch, milk preparations and products, HS20 (vegetable, fruit, nut and other food preparations), and HS22 (beverages, spirits, and vinegar). Overall, China's exports to Korea have become increasingly diversified and biased towards processed products, while the share of traditional products has declined.



(Source: United Nations Statistics Division, Commodity Trade Database; COMTRADE)

Figure 1. Structure of China's Agricultural Exports to Korea



(Source: United Nations Statistics Division, Commodity Trade Database; COMTRADE)

Figure 2. Export Structure of Major Suppliers to the Korean Food Market (1990-2005)

Figure 2 presents a comparison of the export structure of the United States, China and two other exporters - Australia and Argentina- to Korea. The horizontal axis of figure 2 shows the selected agricultural category in two-digit HS codes, while the height of each of the lines in figure 2 indicate the percentage of the particular item in a country's total exports to Korea. For instance, Cereal (HS10) accounts for the largest share of both U.S. and China's exports to Korea. Comparing the importance of each export item for these 4 countries, we find significant overlap in exports of several agricultural products. Most notable is Cereal (HS10), which accounts for a significant share of Australian, Chinese and U.S. exports to Korea. China appears to be directly competing with the United States in categories HS10 (cereal), HS12 (Oil seed), HS20 (vegetable preparations) and HS21 (miscellaneous preparations). Australia also appears to compete with the United States and China in the Korean Cereal import market. We have included Argentina for a comparison with the three large exporters to the Korean market. Argentina seems to have an export structure similar to that of China, but lacks comparable trade volumes.

SIMILARITY INDEX OF EXPORT STRUCTURE

The next step is to measure observed similarities of export structure among China, the United States and other exporters to Korea through quantitative methods. Although several approaches to calculate the relative similarity of export structure between China and other countries are available, we draw on the un-centered correlation distance approach of Jaffe (1986). In the latter study, the technological similarity of firms is measured by the correlation in their research and development (R&D) portfolios. We have adapted Jaffe's (1986) approach to quantify the similarities of export structure among major foreign suppliers to the Korean food market.

To illustrate the un-centered correlation distance approach, we first introduce the commodity composition vector of each exporting country in space $\mathbb{R}^k$:

(1) $F_i = (F_{i1,}, \cdots, F_{ik})$,

where F_i is country i's export commodity vector in which F_{ik} denotes its export value of commodity k to Korea. Equation (1) is rewritten in share form as follows:

$$(2) \quad f_i = (f_{i1}, \cdots, f_{ik}),$$

where f_{ik} is the share of i-th country in the total Korean imports of the k-th commodity. Note that the shares sum to one, i.e., $\sum_i f_{ik} = 1$ for each k. With the export share vector in equation (2), the coefficient of un-centered correlation distance (ω_{ij}) can be defined as follows:

$$(3) \quad \omega_{ij} = \frac{f_i \cdot f_j^{'}}{\|f_i\| \cdot \|f_j\|},$$

where the term $\|f\|$ indicates the vector norm. When ω_{ij} =1, the countries are said to coincide on the commodity space. That is, a similar export structure between two countries will result in a value of ω_{ij} near unity. In contrast, ω_{ij} will take value or approach zero if the two countries in comparison have perfectly different exporting structures, i.e., export different sets of commodities to Korea.

Table 6. Similarity Index of Agricultural Export Structure Compared with China

Top-20 Exporters to Korea	1990-2005	1990-1993	1994-1997	1998-2001	2002-2005
USA	0.54	0.37	0.60	0.57	0.18
Australia	0.05	0.03	0.02	0.08	0.08
Canada	0.05	0.01	0.05	0.03	0.03
Brazil	0.39	0.05	0.14	0.36	0.71
Japan	0.04	0.01	0.05	0.03	0.04
United Kingdom	0.01	0.01	0.01	0.01	0.01
Thailand	0.05	0.00	0.01	0.02	0.02
Netherlands	0.03	0.00	0.01	0.07	0.02
India	0.13	0.13	0.23	0.03	0.07
Philippines	0.04	0.02	0.08	0.04	0.02
Malaysia	0.01	0.00	0.02	0.02	0.01
Germany	0.03	0.01	0.04	0.03	0.03
Indonesia	0.05	0.02	0.07	0.04	0.04
France	0.03	0.01	0.05	0.02	0.02
Argentina	0.68	0.08	0.88	0.73	0.87
Guatemala	0.00	0.04	0.00	0.00	0.00
Spain	0.02	0.00	0.02	0.03	0.03
Viet Nam	0.04	0.08	0.06	0.02	0.02
South Africa	-	-	-	0.06	0.01

We apply the un-centered correlation distance approach to the top 20 exporters to Korea during 1990 to 2005. Since the range and scale of items used in the analysis will significantly affect the measurement of the correlation distance, we employ data disaggregated to four-digit HS code in our analysis. Thus, we have 211 import items, $k = 1, \ldots, 211$, for each of which we have value data and *cif* price in US dollars.[3]

Table 6 presents five sets of results on ω_{ij} corresponding to the entire sample and four sub-samples of our study. Our base country for computing correlation distance is China. In the following, we focus first on the results from the entire sample. Only 3 out of the 20 countries investigated have values of ω_{ij} exceeding 0.30 - Argentina, US and Brazil. The above results show that China's export structure appears similar to that of the above 3 countries. As noted earlier, the value of Argentina's or Brazil's exports to Korea are relatively small and hence, the similarity index, observed in the case of the United States, is of significance. It appears that China's exports, under 211 four-digit HS commodities, are in direct competition with the United States during 1990-2005. The only other country with some export similarities with China in Korean markets is India.

The trend in the similarity index during 1990-2005, in columns 2 through 5 of table 6, reveals the changing nature of competition in the Korean market. From 1990 to 2001, China's export structure was increasingly similar to that of the United States, but the similarity index drops to 0.18 during 2002-2005. The latter result implies that either an export replacement or some deviation in the export structure has occurred between the two major exporters.[4] Recall from table 3 and 5 that Cereal (HS10) is an important group of export for both countries. Thus, any change in export quantities of Cereal between these two countries will have a larger effect on the similarity index. Since the exports of Cereal from China and the United States to Korea show opposite trends, it is reasonable to expect a drop in the similarity index. During 2002-2005, Cereal has lost its long-standing position as the United States' top export item to Korea, with meat products and vegetables becoming relatively more important. However, the United States still has a relatively high similarity index with China during 2002-2005 compared with other top 20 exporters except Brazil and Argentina. Again, the larger and increasing similarity indexes of Brazil and Argentina should be viewed in the context of their relatively lower share of Korean imports. Table 6 also implies that China's exports likely focus on products which are also primary exports of the United States. Hence, we can anticipate intense competition between the United States and China in certain product categories in the Korean food market, and that China's products may be a substitute for U.S. exports.

The similarity indexes of Canada and Australia are relatively lower, indicating that their export structure does not compare well with that of China. India, shows an opposite drift in export structure relative to that of China. From 1990-1997, India's similarity index increased from 0.13 to 0.23, but sharply declined in the following years, which confirms the divergence of its export structure from that of China.

[3] The applicability of the index to processed products may be tenous because of consumers' preference for variety. Our disaggregation to four-digit HS codes alleviates some of this problem, but the trade literature generally assumes fairly large elasticities of substitution among varieties (Feenstra 2003).

[4] As a reviewer noted, exchange rate effects are likely to be a key part of the answer. The U.S. dollar has shown a mixed pattern against Korean Won since 2000, unlike its depreciation episode with major currencies. However, such exchange-rate effects on U.S.-Korean trade can be discerned only using an analytical or econometric model, which is beyond the scope of this paper.

EXPORTERS' RELATIVE SHARE OF KOREAN MARKET

In figure 3, Korean market shares of China and the United States appear to be the opposite of each other. The horizontal axis represents the change in export share during 1990-2005, while the vertical axis denotes the average annual growth rate of exports in the same period for all major exporters to Korea. The radius of each colored circle represents respective country's export volume, i.e., the larger the circle for a country, the larger is its export value to Korea. If a country appears in the first quadrant, it means that its exports have grown on average during 1990-2005 and market share has increased. On the other hand, if the country is plotted on the third quadrant, its export growth has been negative along with a fall in market shares.

China's trade volume is lower relative to the United States, as seen in the size differences of respective circles, but the former's share of Korean import market and annual average growth are higher than those of the latter. From 1990 to 2005, the United States has lost about 19% of market share in the Korean import market, while China has increased its share by approximately 13%. Whereas the American exports, in value terms, to Korea are generally on the decline, China's exports have shown significant growth of nearly 20 percent per annum. Thus, the possible substitution of China's exports for that of the United States seen the similarity index of table 6 is also re-affirmed in figure 3.

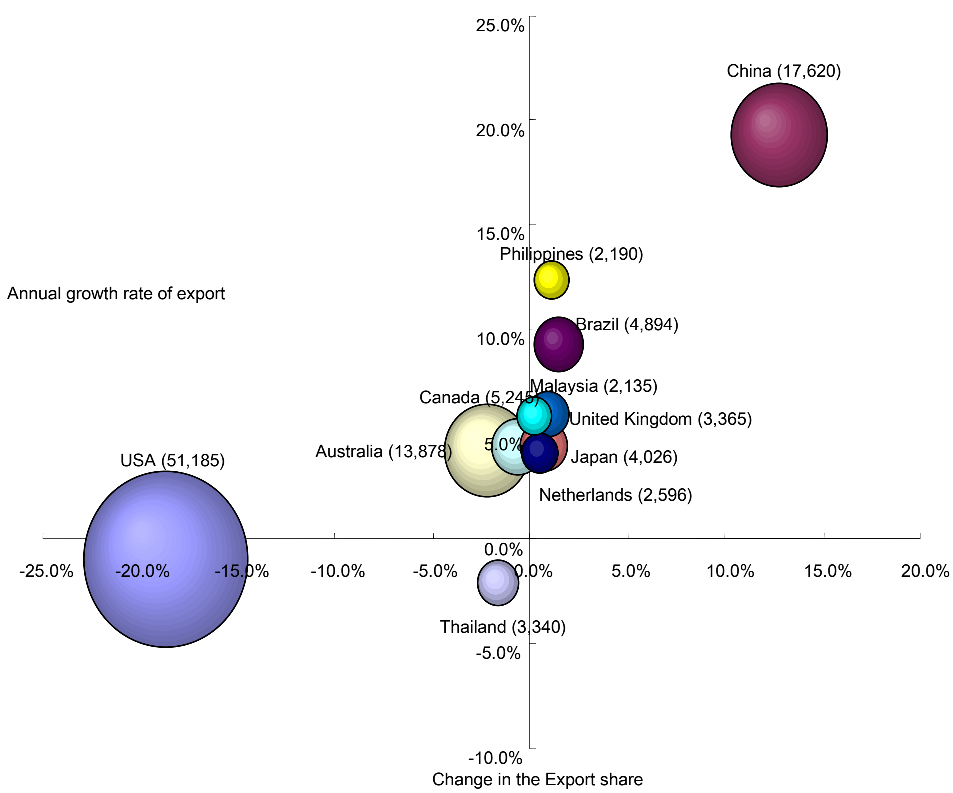


Figure 3. Change in Exporters' Share of the Korean Market

Table 7 depicts the exporters' change in market share and its annual growth rate for four sub-samples as in table 6. During 1990-1993, China's exports to Korea registered dramatic increases with an average annual growth rate of over 63%, which partly reflects the lower base exports in 1990. At the same time, China's market share has grown at an average 12% per year. Caught off-guard, as it appears, the United States' exports to Korea declined at an average rate of 6.92% per year along with an annual 15.12% rate of decline in it share of Korea's total imports. On average over 1994-1997, China's impressive growth in the Korean market continued at 150% per year, but its market share declined at a rate of 3% per year. The latter is a result of robust growth in U.S. exports to Korea averaging 64% per year during 1990-1997. The lower growth rate of U.S. and China's exports to Korea during 1998-2001 should be seen in light of the East Asian Financial Crisis, which led to a significant depreciation of Won, the Korean currency, with respect to that of major trading nations. However, the U.S.-China competitive trend observed during 1990-1993 reappears in 2002-2005, when China's market share gain and export growth are accompanied by the losses in both indicators for the United States.

Table 7. Changes in Exporters' Share of the Korean Market

Top-20 Exporters	Export-Share Change				Annual Growth Rate of Export			
	1990-1993	1994-1997	1998-2001	2002-2005	1990-1993	1994-1997	1998-2001	2002-2005
USA	-15.12%	2.06%	-4.71%	-6.26%	-6.92%	64.37%	-5.81%	-2.96%
China	12.38%	-3.19%	3.21%	3.51%	63.31%	150.4%	-3.05%	16.58%
Australia	-0.80%	-3.22%	1.60%	-0.11%	0.53%	5.95%	0.14%	13.42%
Canada	-0.68%	0.60%	-1.14%	-0.28%	8.54%	-2.10%	-8.91%	14.07%
Brazil	-0.37%	1.27%	-0.06%	1.78%	0.60%	11.96%	4.51%	9.46%
Japan	0.47%	0.55%	-0.40%	-0.22%	10.84%	-6.03%	-3.34%	2.35%
UK	0.08%	0.63%	0.28%	1.80%	2.42%	13.50%	1.80%	-1.15%
Thailand	-0.13%	-1.22%	-1.19%	0.02%	-1.01%	47.05%	-12.01%	-3.22%
Netherlands	1.20%	-0.54%	-0.27%	-0.72%	23.95%	44.86%	-14.40%	9.14%
India	0.63%	0.34%	0.05%	0.39%	26.33%	65.88%	0.22%	-4.26%
Philippines	0.88%	-0.21%	0.46%	-0.09%	23.55%	12.57%	4.17%	15.72%
Malaysia	0.14%	0.09%	-0.12%	-0.28%	6.60%	15.50%	-11.40%	17.30%
Germany	0.91%	0.90%	-0.12%	0.13%	451.41%	-19.13%	-3.23%	7.85%
Indonesia	-0.10%	0.70%	0.06%	-0.27%	4.34%	6.41%	-14.95%	14.65%
France	0.25%	0.26%	0.43%	-0.14%	15.25%	13.51%	4.82%	16.07%
Argentina	0.02%	0.64%	0.26%	0.68%	-42.76%	143.96%	0.85%	9.55%
Guatemala	-0.03%	0.02%	1.00%	0.21%	-43.55%	-16.61%	63.65%	-15.59%
Spain	0.12%	0.06%	0.01%	0.00%	17.84%	2.29%	-6.16%	39.69%
Vietnam	0.17%	0.27%	0.23%	-0.21%	420.10%	0.51%	3.92%	8.08%
South Africa	0.00%	0.00%	0.44%	0.06%	0.00%	0.00%	454.07%	-11.43%

With regard to other countries, Australia has witnessed export growth to Korean markets, but its market share gains are limited. Several countries appear to have had a dramatic increase in exports to Korea especially during 1990-1997 for at least two reasons. The first is that most of these countries' base exports are small and hence, a small increase in exports may result in large growth rates. Furthermore, the implementation of minimum market access requirements of the Uruguay Round Agreement on Agriculture may have resulted in more countries experiencing some increase in exports to Korea.

INDEX OF CHINA'S COMPETITIVE THREAT TO OTHER EXPORTERS TO KOREA

The next step is to an derive index which represents the pattern of competitive threat from China to the United States and other exporters based on the relative market shares in table 7. The analysis of the pattern of competitive threat after 1990 will follow the conceptual framework of Lall and Albaladejo (2004). For an in-depth evaluation, we have categorized the threat of China to other exporters in the Korean market into 5 types: Direct Threat, Partial Threat, No Threat, China under threat, and Mutual Withdrawal. The definitions of each type are as follows.

- Direct Threat (5): China gains market share while its competing country loses market share in the Korean food market, implying that China's export is a direct substitute for that from its competitor.
- Partial Threat (4): Both China and its competitor gain market share, but China shows a higher growth rate of exports.
- No Threat (3): Both China and its competitor gain market share, but China shows lower growth rate.
- China under threat (2): China loses market share, while the competing country shows share growth in the Korean market.
- Mutual Withdrawal (1): The competitor and China both lose market share, which implies that both countries have lost their competitiveness as a whole in the Korean market.
- No export (0): No exports from the competitor.

Table 8. Competitive Threat of China to Top-20 Exporters to Korea

Period	USA	Australia	Canada	Brazil	Japan	UK	Thailand	Nether -lands	India	Mala ysia
1990-1993	5	5	5	5	4	4	5	4	4	4
1994-1997	2	1	2	2	2	2	1	1	2	4
1998-2001	5	3	5	0	5	3	5	5	3	5
2002-2005	5	5	5	4	5	4	4	5	4	5
1990-2005	**5**	**5**	**5**	4	4	4	**5**	4	4	4
1990-1993	3	5	4	4	5	4	3	0	4	
1994-1997	3	4	4	4	3	4	4	0	1	
1998-2001	5	4	3	3	3	4	3	0	3	
2002-2005	4	5	5	4	4	3	5	4	5	
1990-2005	3	4	4	4	3	4	4	3	4	

Note: (0) No export, (1) Mutual Withdrawal, (2) China under threat, (3) No Threat, (4) Partial Threat, (5) Direct Threat.

Tables 8, 9 and 10 present the results from the application of the concept of competitive threat with China as the base against the United States and other exporters. The first of the three tables confirms that China's exports are a Direct Threat to the United States, Australia, Canada, Brazil, Thailand, Indonesia and Guatemala. With the exemption of Germany, Guatemala, and the Republic of South Africa, table 8 shows that a total of 16 countries face either Direct or Partial Threat from China when exporting to the Korean market. There are some variations in the trend of these indexes during 1990-2005, but generally the results show that China has been a competitive threat to most, if not all, major agricultural exporters to Korea (Im 2002).

Table 9 presents the percent of commodity lines facing various degrees of competitive threat from China. About 52.6% of the 173 U.S. products are subject to Direct Threat from China. No other country faces similar Direct Threat levels from China. In total, about 83.8% of U.S. product lines face either Direct or Partial Threat from China in Korean markets. A number of developing countries such as India, Indonesia, Malaysia and Thailand face Partial Threat from China in about half of their product lines exported to Korea (Shafaeddin 2004).

Table 9. Number of Products by Type of Competitive Threat from China (Four-digit HS Code, 1990-2005)

Top-20 Exporters	Direct Threat	Partial Threat	No Threat	China under Threat	Mutual Withdrawal	Total
USA	91 (52.60)	54 (31.20)	25 (14.50)	0 (0.00)	3 (1.70)	173
Australia	24 (14.70)	71 (43.60)	51 (31.30)	12 (7.40)	5 (3.10)	163
Canada	30 (21.60)	55 (39.60)	40 (28.80)	12 (8.60)	2 (1.40)	139
Brazil	16 (19.00)	39 (46.40)	24 (28.60)	4 (4.80)	1 (1.20)	84
Japan	83 (47.70)	53 (30.50)	19 (10.90)	11 (6.30)	8 (4.60)	174
United Kingdom	35 (28.50)	63 (51.20)	20 (16.30)	0 (0.00)	5 (4.10)	123
Thailand	35 (29.70)	49 (41.50)	31 (26.30)	0 (0.00)	3 (2.50)	118
Netherlands	41 (28.90)	53 (37.30)	34 (23.90)	7 (4.90)	7 (4.90)	142
India	19 (17.90)	55 (51.90)	26 (24.50)	4 (3.80)	2 (1.90)	106
Philippines	26 (32.10)	36 (44.40)	19 (23.50)	0 (0.00)	0 (0.00)	81
Malaysia	14 (13.70)	48 (47.10)	29 (28.40)	10 (9.80)	1 (1.00)	102
Germany	0 (0.00)	69 (48.90)	55 (39.00)	17 (12.10)	0 (0.00)	141
Indonesia	24 (20.30)	53 (44.90)	32 (27.10)	8 (6.80)	1 (0.80)	118
France	31 (20.10)	70 (45.50)	37 (24.00)	10 (6.50)	6 (3.90)	154
Argentina	4 (5.50)	40 (54.80)	19 (26.00)	7 (9.60)	3 (4.10)	73
Guatemala	2 (14.30)	5 (35.70)	5 (35.70)	2 (14.30)	0 (0.00)	14
Spain	10 (11.10)	50 (55.60)	26 (28.90)	0 (0.00)	4 (4.40)	90
Viet Nam	0 (0.00)	92 (95.80)	4 (4.20)	0 (0.00)	0 (0.00)	96
South Africa	0 (0.00)	27 (55.10)	22 (44.90)	0 (0.00)	0 (0.00)	49

Number in parenthesis is percent of total number of products

To further illustrate the extent of competitive threat from China, we carry out an in-depth examination of Korean Cereal imports, where China, the United States and Australia are major players. Within Cereal (HS10), we compute threat levels for 8 four-digit commodities. Table 10 shows that the United States has been directly threatened by China in all cereal categories with the exemption of 1003 (Barley) and 1008 (Buckwheat, Millet, Canary Seed and other Cereals).Most exporters of corn (HS1005) and wheat (HS1001) face either Direct or Partial Threat from China's exports.[5]

Table 10. Competitive Threat of China in HS 10 (Cereal) 1990-2005

Top-20 Exporters	1001	1002	1003	1004	1005	1006	1007	1008
USA	5	5	4	5	5	5	5	4
Australia	4	3	4	4	3	4	3	5
Canada	4	5	5	5	4	0	4	4
Brazil	0	4	0	0	3	0	0	0
Japan	0	0	0	4	5	4	5	4
U.K.	4	4	4	0	4	0	0	0
Thailand	5	0	0	0	5	5	0	5
Netherlands	4	4	4	0	4	4	0	0
India	4	4	0	0	4	5	4	0
Philippines	0	0	0	0	4	4	0	0
Malaysia	0	0	0	0	4	4	0	0
Germany	4	4	4	0	0	4	0	0
Indonesia	3	0	0	0	4	0	0	0
France	4	4	0	0	4	0	0	0
Argentina	4	0	0	0	3	0	4	5
Guatemala	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0
Vietnam	0	0	0	0	4	4	0	4
South Africa	0	0	0	0	4	0	0	0

CONCLUSION

Korea, a large net-food importing country, is rapidly opening its doors to agricultural imports from the rest of the world. The recent free trade agreement with Chile and others in the making are expected to increase the openness of the economy and the competition in Korean food markets. Moreover, these agreements are acting as a strong signal to other major players in the global economy that Korea, once regarded as one of the most closed economies in terms of agriculture, is striving to transform itself into an open agricultural economy. With high per capita income, Korea is a highly-desired market for several agricultural exporters.

[5] We explored beta convergence in export shares, i.e., is the rate of share change positively associated with base period shares? In a simple regression using data on the top 20 exporters to Korea, the beta-convergence coefficient is not statistically significant. The two top exporters, United States and China, have similar export structure, and so, we are unable to document how commodity composition may affect the rate of share change.

The objective of this article to investigate the nature and extent of competition among foreign suppliers to the Korean food market. In particular, we examine China's impact on the Korean food market, which will help understand the changing relationship between Korea and its agricultural trade partners, especially the United States. For this purpose, we have employed two frameworks. The first is the un-centered correlation distance, which helped uncover the similarities in the export structures of countries competing to serve the Korean market. The second framework is the concept of competitive threat, through which we have determined the competitive relationship between any two exporters, by comparing their growth rate of exports and export shares to Korea. The combined results of these two frameworks allowed us to investigate the changing roles of China, the United States, and other countries in the Korean import market.

The results show that the United States, traditionally a large food exporter to Korea, is facing serious competition from China's exports. The similar export structures of China and the United States have made the latter vulnerable to competition during the last two decades. With increased globalization, characterized by the URAA, China's accession to WTO and other global events (e.g., currency appreciation/depreciation), the geographic proximity of China to Korean markets confers the former several advantages in its competition with the United States. For instance, China possesses varieties and breeds of agricultural products similar to those in Korea and also benefits from lower transport costs. This is especially visible in cereal markets, where both countries have increased exports to the world, but show opposite trends in the Korean market. The market share of U.S. products has rapidly declined while that of China has witnessed dramatic growth.

Using the concept of competitive threat, we show that China poses a Direct or Partial Threat to the United States in virtually every agricultural product exported to Korea. Among 173 U.S. products exported to Korea, 91 are directly threatened by China's products, and 54 items face a Partial Threat. That is, about 80% of U.S. export product lines in the Korea market are challenged by China's exports.

With the recently signed Korea-United States Free Trade Agreement waiting for approval in both countries, it would be interesting to see how the elimination of trade barriers will affect the U.S. position in the Korean market. Additional research will be needed to assess the effects of trade and non-trade barriers, which immediately favor U.S. products, as well as the importance of factors such as low costs, similar breeds of crop, and geographical proximity, which favor Chinese products. Furthermore, the possibility of a Korea-China Free Trade Agreement increases the complexity of trade patterns and competition, which will remain an important topic for future research.

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THE ECONOMIC DETERMINANTS OF CROP DIVERSITY ON FARMS IN RURAL BANGLADESH

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ABSTRACT

The study examines the economic determinants of crop diversity using a survey of 406 farmers located in 21 villages in three agro-ecological regions of Bangladesh. The computed value of diversity indices of crop concentration (Herfindahl), richness (Margalef) and evenness (Shannon) confirm that farming system in Bangladesh is still relatively diverse despite four decades of thrust in the diffusion of a rice-based 'Green Revolution' technology. Results reveal that a host of price and non-price factors significantly influence farmers' decision to diversify. Likelihood of diversification increases with a fall in the prices of fertilizers, animal power services and modern rice and a rise in the price of cash crops. Crop diversification is positively influenced by farm size, livestock ownership, farming experience, education, membership in NGOs, regions with developed infrastructure and unavailability of irrigation. Also, diversification is higher among owner operators. Therefore, crop diversification can be promoted significantly by investing in rural infrastructure, farmers' education, and supporting NGOs working at the grassroots level. Price policies aimed at improving cash crop prices and reducing fertilizer and animal power prices will also promote diversification. In addition, land reform policies focusing on delegating land ownership to landless/marginal farmers and policies to improve the livestock sector in order to promote livestock ownership by individual farmers are also noteworthy.

Key words: Crop diversity, socio-economic factors, Tobit model, Bangladesh.
JEL Classification: O33; Q18; C21

INTRODUCTION

The economy of Bangladesh is largely dependent on agriculture. Although, rice production dominates the farming system of Bangladesh, accounting for 70% of the gross cropped area (BBS 2001), several other crops are also grown in conjunction with rice in order to fulfil a dual role of meeting subsistence as well as cash needs. Since the beginning of 1960s, Bangladesh has pursued a policy of rapid technological progress in

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agriculture leading to diffusion of a rice-based 'Green-Revolution' technology package. As a result, farmers concentrated on producing modern varieties of rice all year round covering three production seasons (*Aus* - pre-monsoon, *Aman* - monsoon and *Boro* - dry winter), particularly in areas that are endowed with supplemental irrigation facilities. This raised concern regarding loss of crop diversity, consequently leading to an unsustainable agricultural system. For example, Husain, Hossain and Janaiah (2001) noted that the intensive monoculture of rice led to a displacement of land under low productive non-rice crops such as pulses, oilseeds, spices and vegetables, leading to an erosion of crop diversity, thereby, endangering the sustainability of crop-based agricultural production system. Mahmud, Rahman and Zohir (1994) also noted that "the area under non-cereal crops has continuously fallen since late 1970s, mainly due to the expansion of irrigation facilities, which led to fierce competition for land between modern *Boro* season rice and non-cereals". However, an analysis of the level of crop diversification between the two Agricultural Censuses of 1960 and 1996 reveals a different story.

Table 1 presents the cropped area, cropping intensity and the level of crop diversification between the Agricultural Censuses of 1960 and 1996, respectively. The former census just precedes the onset of Green Revolution while the latter census is the latest available to date, and is comprehensive in nature, scope and content. It is clear from table 1 that, although there were dramatic changes in the structure of the farms and rise in cropping intensity, the level of crop diversification changed only moderately over a 36-year period.

With a boom in population growth between the two censuses, the average operational size per farm shrunk dramatically. The large and medium farms gave way to small farms largely because of increase in the number of farms competing for a fixed amount of cultivable land. The decline in net cropped area by 12.7 percent is largely offset by a 26 percent rise in cropping intensity, thereby, leaving gross cropped area slightly positive (a 2.5 percent increase). An examination of the crop shares reveal that the share of cereals (rice, wheat and other minor cereals) increased by only 1.7 percent in 36 years. The main changes were in the composition of modern varieties of rice, which replaced the traditional varieties. Also, there was a five-fold increase in modern wheat area. The non-cereal crops used to account for 23.4 percent of the gross cropped area in 1960 and now accounts for 21.7 percent in 1996, a negligible decline of 1.4 percent in 36 years. However, there has been a shift in the composition of non-cereals over this period. The areas under pulses, cash crops and spices declined sharply, while areas under oilseeds and vegetables increased over this period. As a result, contrary to expectation, crop diversity in agriculture (as revealed by the computed Herfindahl index of crop concentration) has actually increased by 4.5 percent over a 36 year period, which can hardly be justified as a serious replacement of land area by rice monoculture. The Herfindahl index of crop concentration was computed at 0.59 in 1960 and 0.54 in 1996.

There is an apparent paradox in that many non-cereal crops (e.g., potatoes, vegetables, onions and cotton) are more profitable (both in economic and financial terms) than modern rice cultivation, which was mainly attributed to high risk as well as incompatibility of the existing irrigation system to produce non-cereals in conjunction with rice (Mahmud, Rahman and Zohir 1994). However, it has been increasingly recognized that, under non-irrigated or semi-irrigated conditions, better farming practices and varietal improvements in non-cereal crops will be more profitable and could lead to crop diversification as a successful strategy for the future growth and sustainability of Bangladeshi agriculture (MoA 1989; Mahmud, Rahman and Zohir 1994; PC 1998). The Fifth Five Year Plan (1997–2002) set specific objectives to attain self-sufficiency in foodgrain production along with increased production of other nutritional crops, as well as to encourage export of vegetables and fruits, while keeping in view the domestic needs (PC 1998). The Plan also earmarked Tk 1,900 million (US$ 41.8 million) accounting for 8.9 percent of the total agricultural allocation to promote crop diversification. Such an emphasis at the policy level points toward the importance of identifying the determinants of farmers' crop choice decisions, so that an informed judgment can be made about the suitability of crop diversification as a desired strategy for promoting agricultural growth in Bangladesh.

Table 1. Changes in Cropped Area, Cropping Intensity and Crop Diversification Between Censuses of 1960 and 1996

dicators	Census 1960	Census 1996	Inter-census change (%)
Number of farms	6,139,480	11,798,242	92.17
% of small farms (0.02 – 1.01 ha)	51.63	79.87	197.26
% of medium farms (1.01 – 3.03 ha)	37.68	17.61	-10.19
% of large farms (above 3.03 ha)	10.69	2.52	-54.63
Operated area (ha)	7,744,929	8,076,369	4.28
Net temporary cropped area (ha)	7,627,372	6,655,771	-12.74
Gross cropped area (ha)	11,283,169	11,580,666	2.64
Operated area per farm (ha)	1.26	0.68	-45.74
Net temporary cropped area per farm (ha)	1.24	0.56	-54.59
Gross cropped area per farm (ha)	1.84	0.98	-46.59
Proportion of cropped area under (%)			
Rice	75.76	72.80	-1.37
Wheat and other minor cereals	0.83	5.52	585.35
Pulses	6.31	4.63	-24.72
Oilseeds	2.82	4.14	50.92
Cash crops	8.74	6.32	-25.77
Vegetables	2.22	3.55	64.49
Spices and other miscellaneous crops	3.33	3.04	-6.34
Cropping intensity (all farms)	148	174	26.00
Small farms	167	187	20.00
Medium farms	152	171	19.00
Large farms	135	154	19.00
Herfindahl index of crop concentration (all farms)	0.59	0.54	-4.50
Small farms	0.57	0.52	-4.59
Medium farms	0.59	0.55	-4.23
Large farms	0.60	0.59	-0.79

Source: Adapted from Rahman (2009).

Given this backdrop, the present study is aimed at determining the underlying factors affecting crop diversity on farms in rural Bangladesh. We estimate a model of crop choice in a theoretical framework of the farm household model applying a micro-econometric approach.

METHODOLOGY

Theoretical Model

We develop a general model of farm production to examine the determinants of crop diversity. The farmer produces a vector Q of farm outputs using a vector of inputs X. The decision of choice, however, is constrained by a given production technology that allows combination of inputs (X) and an allocation of a fixed land area ($A = A^0$) among j number of crops, given the characteristics of the farm (Z). The total output of each farmer i is given by a stochastic quasi-concave production function:

$$Q_{ij} = f(X_{ijk}....X_{ijk}, \varepsilon \mid A_i, Z_i) \qquad (1)$$

where ε is the stochastic variable indicating impacts of weather conditions or random noise. It is assumed that $f_{Xk}>0$ and $f_{XXk}<0$. Each set of area shares (α_j) among j crops sums to 1, $\sum_j^J \alpha_j = 1, j = 1,2,....J$, which maps into the vector Q through physical input-output relationships. The choice of area shares implies the level of farm outputs. The profit of each farm i is given by:

$$\pi_i(Q, X, p, w \mid A_i, Z_i) = \sum_{j=1}^{J} p_j Q_{ij} - \sum_{k=1}^{K} w_j X_{ijk} \qquad (2)$$

where p is the vector of output prices and w is the vector of input prices.

The farmer is assumed to have a von Neuman-Morgenstern utility function, $U(W)$ defined on wealth W with $U_W>0$ and $U_{WW}<0$. The wealth is represented by the sum of initial wealth (W_0) and the profit generated from farming (π). Therefore, the objective of each farm is to maximize expected utility as (Isik 2004):

$$EU(W_0 + \pi(Q, X, p, w \mid A_i, Z_i) \qquad (3)$$

where E is the expectation operator defined over ε. The choice variables in (3), the farm's input levels X_{ijk}, are characterized by the first-order conditions

$$\frac{\partial EU}{\partial X_{ijk}} = EU_w(p_j * f_{Mijk} - w_k) = 0 \qquad (4)$$

The second-order conditions are satisfied under risk aversion and a quasi-concave production function (Isik 2004). The optimal input mix is given by:

$$X_{ijk}^* = X_{ijk}^*(p_j, w_k, U \mid A_i, Z_i) \qquad (5)$$

And the optimal output mix, depending on (X_{ijk}^*) is defined as:

$$Q_{ij}^* = f(X_{ij1}^*,......X_{ijk}^*) \mid A_i, Z_i) \qquad (6)$$

Factors Affecting Choice of Crops

To determine the factors affecting a farmer's choice of crops, we derive the equivalent wealth or income from the expected utility:

$$E_i = E(W_0 + \pi_i(Q, X, p, w \mid A_i, Z_i) \qquad (7)$$

This equivalent wealth or income in a single decision making period is composed of net farm earnings (profits) from crop production and initial wealth that is 'exogenous' to the crop choices (W_0), such as farm capital assets and livestock resources carried over from earlier period.

Under the assumption of perfect market, farm production decisions are made separately from consumption decisions and the household maximizes net farm earnings (profits) subject to the technology and expenditure constraints (Benin et al. 2004). Therefore, production decision of the farms, such as crop choices, are driven by net returns (profits), which are determined only by input and output prices, farm physical characteristics and socio-economic characteristics of the farm household (Benin et al. 2004). Therefore, the optimal choice of the household can be re-expressed as a reduced form function of input and output prices, market wage, farm size, initial wealth, and household and farm characteristics:

$$h_i^* = h_i^*(p_j, w_k, Z_i, A_i, W_{0i}) \qquad (8)$$

Eq. (8) forms the basis for econometric estimation to examine the factors affecting diversity of crops on household farms, an outcome of choices made in a constrained optimization problem. Diversity of crops (*D*) for each farm *i* is expressed in the following conceptual form (Benin et al., 2004):

$$D_i = D_i(\alpha_{ij}^*(p_j, w_k, Z_i, A_i, W_{0i}) \qquad (9)$$

Data and the Study Area

The study is based on farm-level cross section data for the crop year 1996 collected from three agro-ecological regions of Bangladesh. The survey was conducted from February to April 1997. Samples were collected from eight villages of the Jamalpur Sadar sub-district of Jamalpur, representing wet agro-ecology, six villages of the Manirampur sub-district of Jessore, representing dry agro-ecology, and seven villages of the Matlab sub-district of Chandpur, representing wet agro-ecology in an agriculturally advanced area. A multistage random sampling technique was employed to locate the districts, then the *Thana* (sub-districts), then the villages in each of the three sub-districts, and finally the sample households. A total of 406 households[1] from these 21 villages were selected. Detailed crop input-output data at the plot level for individual farm households were collected for ten crop groups[2]. The dataset also includes information on the level of

[1] The sample households were selected based on the information on the total number of households including their land ownership categories, which were obtained from BRAC (a national non-governmental organization). Then a stratified random sampling procedure was applied using a formula from Arkin and Colton (1963) that maximizes the sample size with a 5% error limit. Farm size categories (large, medium, and small farmers) were used as the strata (for details, see Rahman 1998).

[2] The crop groups are: traditional rice varieties (Aus – pre-monsoon, Aman – monsoon, and Boro – dry seasons), high yielding/modern rice varieties (Aus, Aman, and Boro seasons), modern/high yielding wheat varieties, jute, potato, pulses, spices, oilseeds, vegetables, and cotton. Pulses in turn include lentil, mungbean, and gram. Spices include onion, garlic, chilli, ginger, and turmeric. Oilseeds include sesame, mustard, and groundnut. Vegetables include eggplant, cauliflower, cabbage, arum, beans, gourds, radish, and leafy vegetables.

infrastructural development[3] and soil fertility determined from soil samples collected from representative locations in the study villages[4].

Dependent Variables: Diversity Indices

The dependent variables are the diversity indices, where each diversity index (*D*) is a scalar constructed from the vector of area shares allocated to crops. The crop groups are mentioned in footnote#2. We employ three indices, of which two have been adapted from the ecological indices of spatial diversity in species (Margalef and Shannon indices) and one from the marketing industry index of market concentration (Herfindahl index) (Table 2). Each index represents a unique diversity concept. Richness, or the number of crops observed is measured by a Margalef index. Evenness, which combines both richness and relative abundance concept, is measured by a Shannon index (Benin et al. 2004), and the concentration of crop type is measured by a Herfindahl index.

Table 2. Dependent Variables Used in the Analysis of Crop Diversity on Farms

Index	Concept	Construction	Explanation	Interpretation
Margalef	Richness	$D_M = (S-1)/\ln A,\ D_M \geq 0$	*A* = total area planted to all crops by the household, *S* is the number of crops.	Higher value of index denotes higher diversity
Shannon	Evenness or equitability (both richness and relative abundance)	$D_S = -\sum \alpha_j * \ln \alpha_j,\ D_S \geq 0$	α_j = area share occupied by the *jth* crop in *A*.	Higher value of index denotes higher diversity
Herfindahl	Concentration	$D_H = \sum \alpha_j^2,\ 0 \leq D_H \leq 1$	α_j = area share occupied by the *jth* crop in *A*.	A zero value denotes perfect diversification and a value of 1 denotes perfect specialization

Source: After Benin et al. (2004); Bradshaw (2004) and Llewelyn and Williams (1996).

[3] A composite 'index of underdevelopment of infrastructure' was constructed using the cost of access approach. A total of 13 elements are considered for its construction. These are primary market, secondary market, storage facility, rice mill, paved road, bus stop, bank, union office, agricultural extension office, high school, college, thana (sub-district) headquarters, and post office (see Ahmed and Hossain 1990 for construction details).

[4] The 'soil fertility index' was constructed from test results of soil samples collected from the study villages during the field survey. Ten soil fertility parameters were tested. These are soil pH, available nitrogen, available potassium, available phosphorus, available sulfur, available zinc, soil texture, soil organic matter content, cation exchange capacity of soil, and electrical conductivity of soil (for details of sampling and tests, see Rahman and Parkinson 2007; Rahman 1998).

Independent Variables

Independent variables are operational measurements of the vectors shown in the right hand side of Eq. (6). The variables incorporated in the econometric models were: three output prices (modern rice, jute, cash crops[5]), four input prices (fertilizers, animal power services, labor, and pesticides), amount of land cultivated, livestock ownership, value of farm capital assets, irrigation, tenurial status, farmers' education, farming experience, subsistence pressure, extension contact in the past one year, membership in NGOs, index of underdevelopment of infrastructure, soil fertility index, and regional dummies for Comilla and Jessore. The definition and measurement of all these variables are presented in table 5. The justification for including these variables in the model is discussed below.

Land is the scarcest resource in Bangladesh, and farm size largely determines the level and extent of income to be derived from farming. Land also serves as a surrogate for a large number of factors as it is a major source of wealth and influences decision to choose crops. Also, greater farm areas can be allocated among more crops (Benin et al. 2004). However, the impact of tenancy on the extent of modern rice technology adoption among farmers is varied (Hossain, et al. 1990). Hence, the amount of land cultivated (to represent wealth) and the proportion of land rented-in (to represent tenurial status) were incorporated to test their independent influence on decisions regarding crop diversity.

Farmers in Bangladesh are not only land poor, but also resource poor. The farm capital asset variable (which includes the value of all tools and equipments used directly into farm operations) was included to examine its influence on crop diversity. Livestock, as a measure of wealth, have an ambiguous effect. Livestock ownership is expected to contribute positively to crop diversity through ensuring draught power for ploughing when needed (Benin et al. 2004).

Access to modern irrigation facilities is an important pre-requisite for growing modern rice, particularly the modern *Boro* rice grown in the dry winter season. Lack of access to modern irrigation facilities has been identified as one of the principal reasons for stagnation in the expansion of modern rice area, which currently accounts for a little over 50 percent of total rice area (Rahman and Thapa 1999; Mahmud, Rahman and Zohir 1994). Also, irrigation may decrease diversity through uniform moisture conditions (Benin et al. 2004).

Use of farmers' education level as explanatory variable in technology adoption studies is common (e.g., Nkamleu and Adesina 2000; Adesina and Baidu-Forson 1995). The education variable was used as a surrogate for a number of factors. At the technical level, access to information as well as capacity to understand the technical aspects and profitability related to different crops may influence crop production decisions. The justification of including farming experience is straightforward[6]. Experienced farmers are more likely to be open to choices regarding crops, be it modern rice or non-rice crops.

Agricultural extension can be singled out as one of the important sources of information dissemination directly relevant to agricultural production practices, particularly in nations like Bangladesh where farmers have very limited access to information. This was reinforced by the fact that many studies found a significant influence of extension education on adoption of land-improving technologies (e.g.,

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[5] This output price variable is constructed by summing up the gross value of all individual crops (excluding all types of rice and jute) and dividing by the total volume of output. Correlation among the three output prices used in these models (modern rice, jute and cash crops) is very low (r=0.19) and is not significantly different from zero.

[6] We did not include age because it is mainly used to act as a proxy for farming experience, which we have already included.

Adesina and Zinnah 1993). Therefore, this variable was incorporated to account for its influence on adoption decisions.

According to Chayanovian theory of the peasant economy, higher subsistence pressure increases the tendency to adopt new technology, and this has been found to be the case in Bangladesh (Hossain et al. 1990; Hossain 1989). The subsistence pressure variable, measured by family size per household was incorporated to account for its influence on crop choices.

The effect of the gender composition of the household is difficult to predict, while household size is expected to increase diversity through preference heterogeneity and labor capacity (Benin et al. 2004). We have, therefore, added proportion of male working members in the household in order to capture the influence of male labor capacity in crop choice decisions[7].

Infrastructure affects agricultural production indirectly through prices, diffusion of technology and use of inputs and has profound impact on the incomes of the poor (Ahmed and Hossain 1990). The state of infrastructure implies improved access to markets and institutions as well as better access to information and hence may influence farmers' crop choices. Also, when improved market infrastructure reaches a village, new trade possibilities emerges, adding crops and production possibilities to the range of economic activities undertaken (Benin et al. 2004). This effect was captured by the index of underdevelopment of infrastructure.

Soil fertility is a key factor that exerts a positive influence on productivity (Rahman and Parkinson 2007), which in turn may influence decision to choose crops. Finally, we include two dummy variables for regional location as a determinant of diversity to capture the cultural and physical environment in which farmers make their decision (Benin et al. 2004).

Regression Structure

The general structure of the regression equation is given by:

$$D_i = a_i + b_i p + c_i w + d_i Z + e_i \qquad (10)$$

where D represents any one of the three indices, the Margalef index of richness or the Shannon index of evenness or the Herfindahl index of concentration, p is a vector of output prices, w is a vector of input prices, Z is a vector of farm and household characteristics, e is the error term controlling for the unobserved factors and/or random noise, and *a, b, c* and *d* are the parameters to be estimated.

A major estimation problem was encountered as a large proportion of households grew only one crop. In this case, both the Margalef and Shannon indices are censored at zero. In such case, Tobit model is most appropriate because it uses all observations, both those are at the limit, usually zero and those above the limit, to estimate a regression line, as opposed to other techniques that uses observations, which are only above the limit value (McDonald and Moffit 1980). The stochastic model underlying Tobit may be expressed as follows (McDonald and Moffit 1980):

[7] Although female labor are also used to some extent in farming in Bangladesh (Rahman 2000), the dominant labor force in farming is still male.

$$
\begin{aligned}
y_m &= X_m\beta + u_m && \text{if } X_m\beta + u_m > 0 \\
&= 0 && \text{if } X_m\beta + u_m \leq 0, \\
& && m = 1,2,......M, \qquad (11)
\end{aligned}
$$

where M is the number of observations, y_m is the dependent variable (diversity index), X_m is a vector of independent variables representing technology attributes and farm and farmer specific socio-economic characteristics, β is a vector of parameters to be estimated, and u_m is an independently distributed error term assumed to be normal with zero mean and constant variance σ^2. The model assumes that there is an underlying stochastic index equal to ($X_m\beta + u_m$), which is observed when it is positive, and hence qualifies as an unobserved latent variable. The relationship between the expected value of all observations, E_y and the expected conditional value above the limit E_y* is given by:

$$E_y = F(z)\, E_y^*$$

where $F(z)$ is the cumulative density normal distribution function and $z = X\beta/\sigma$.

On the other hand, when farm households grow only a single crop, the Herfindahl index is computed as 1. Also, none of the farm households in our sample could reach the perfect diversification score of 0. In our sample, the minimum value of the Herfindahl index of crop concentration was 0.18 while a substantial number scored a maximum of 1. Therefore, Ordinary Least Squares (OLS) regression is best suited for this model because it has the BLUE (Best Linear Unbiased Estimator) properties.

As a result, Tobit regression was applied to estimate the parameters of the crop richness (Margalef index) and crop evenness (Shannon index) models and OLS regression was applied to crop concentration (Herfindahl index) model. Parameters for all the models were estimated using NLOGIT-4 software program (ESI 2007).

RESULTS

Level of Crop Diversification

Table 3 presents the existing cropping practice and the extent of crop diversity amongst the sampled households in each region. It is clear from table 3 that there are substantial variations among the regions with respect to each of the aspects considered. Although 51 percent of the total farmers adopted modern rice monoculture, a substantial 37 percent of the total farmers adopted both modern rice as well as a diversified cropping system. In terms of area allocated to crops, the non-rice crops cover an estimated 19 percent of gross cropped area. In fact, farmers produce a wide range of crops in a cropping year. The mean number of crops grown is estimated at 3.6 with a maximum of 11 crops in a year. The lower panel of table 3 presents the actual measure of crop diversity using the three indices of richness, evenness and concentration. All the three indices clearly indicate that cropping system in Bangladesh is relatively diverse, particularly in Jessore region, where the level of modern rice technology adoption is lowest.

Table 3. Extent of Crop Diversity Among Sampled Farmers

Variables	Comilla	Jessore	Jamalpur	All region
Proportion of farmers:				
Only modern rice adopter	0.51	0.27	0.65	0.51
Only diverse crop adopter	0.16	0.23	0.02	0.12
Adopter of both diversified crop and modern rice	0.33	0.50	0.33	0.37
Proportion of gross cropped area under:				
Modern rice only	0.65	0.32	0.63	0.56
Diverse crops (excluding all types of rice)	0.22	0.37	0.07	0.19
Traditional rice only	0.13	0.31	0.30	0.25
Average number of crops grown in one year	3.34	4.19	3.35	3.57
Standard deviation	1.57	2.16	1.73	1.85
Maximum number of crops grown in one year	8.00	11.00	10.00	11.00
Crop diversification indices of				
Species concentration (Herfindahl index)	0.69	0.46	0.63	0.60
Species richness (Margalef index)	0.28	0.43	0.24	0.30
Species evenness (Shannon index)	0.55	0.96	0.59	0.67
Number of observations (farm households)	126	105	175	406

Notes: The actual data were collected at plot level. Therefore, the total plot level observations of all types of crops grown by these 406 farmer stands at 1,448. Number of observations of modern rice = 622 (Aus = 25, Aman = 150, and Boro = 447); traditional rice = 324 (Aus = 37, Aman = 266, and Boro = 21); and diverse crops = 502 (wheat = 103, jute = 92, potatoes = 59, pulses = 70, spices = 47, oilseeds = 71, vegetables = 44, and cotton = 16). Pulses in turn include lentil, mungbean, and gram. Spices include onion, garlic, chilly, ginger, and turmeric. Oilseeds include sesame, mustard, and groundnut. Vegetables include eggplant, cauliflower, cabbage, arum, beans, gourds, radish, and leafy vegetables.

Table 4 presents the input use rates classified by the level of farm diversification. We designated farms censored at zero as the 'specialized farms[8]' who happens to grow only a single crop of modern rice, and the others as the 'diversified farms'. It is clear from table 4 that the operational size of diversified farms is significantly higher and the use rates of inputs per hectare, except pesticides and irrigation, are significantly lower. The use rates of labor, animal power services and fertilizers are 25, 13 and 19 percent lower among diversified farms compared with those of specialized farms[9]. Although the gross value of output is significantly higher for specialized farms, profits are similar between specialized and diversified farms, due to significantly lower use of inputs by the latter.

Summary statistics of the variables used in the regression analyses are presented in table 5. The farm-specific variables provide a summary of the characteristics of these farms. The amount of land cultivated per farm is 0.98 ha. The average level of education is less than four years; experience in farming is 26 years; average family size is six persons; 22 percent of income is derived off-farm; and only 13 percent of farmers have had contact with extension officers during the past year.

[8] The specialized farms are those which scored zero values for both Margalef and Shannon indices, which in turn scored 1 on Herfindahl index.

Table 4. Profitability and Input Use Rates of Diversified and Specialized Farms

Variables	Diversified Farms	Specialized Farms	Mean Difference (Diversified vs. Specialized)	t-ratio
Land area cultivated (ha)	1.17	0.53	0.56	4.99***
Labor (days/ha)	92.62	123.86	-31.24	-6.85***
Animal power services (pair-days/ha)	26.34	30.37	-4.04	-4.45***
Fertilizer (kg/ha)	212.37	262.74	-50.37	-6.30***
Pesticides (Taka/ha)	288.96	306.50	-17.54	-0.38
Irrigation (Taka/ha)	1,587.16	1,528.68	58.47	0.44
Gross value of output (Taka/ha)	22,164.46	24,470.43	-2,305.86	-2.99***
Profits (Taka/ha)	12,616.01	13,202.84	-586.83	0.82
Number of farms	299	107		

Notes: Profits = (gross value of output – variable cost of all inputs). *** = significant at 1 percent level (p<0.01)

Table 5. Summary Statistics of the Variables Used in the Models

Variables	Unit of Measurement	Mean	Standard Deviation
Price variables			
Fertilizer price	Taka per kg	5.85	1.38
Animal power price	Taka per animal pair-days	83.56	17.34
Labor wage	Taka per person-day	44.67	8.22
Pesticide price	Taka per 100 gm/ml	1015.14	1300.95
Modern rice price	Taka per kg	7.57	2.61
Jute price	Taka per bale	9.59	0.88
Cash crop price (overall)	Taka per kg	4.95	2.35
Socio-economic characteristics of farm and household			
Amount of land cultivated	Hectare	0.98	1.02
Farming experience	Years	25.51	14.21
Education of farmer	Completed year of schooling	3.74	4.26
Family size	Persons per household	6.02	2.53
Ratio of working male member	Number	0.27	0.15
Value of livestock owned	Thousand taka	7.79	8.38
Other farm capital asset	Thousand taka	4.19	12.95
Amount of loan taken	Thousand taka	4.08	13.29
Tenurial status	Proportion of land rented in	0.20	0.29
Irrigation	Proportion of land under irrigation	0.62	0.30
Extension contact	Dummy (1 if had contact, 0 otherwise)	0.13	0.33
Membership in NGOs	Dummy (1 if member, 0 otherwise)	0.29	0.45
Infrastructure index	Number	33.32	14.95
Soil fertility index	Number	1.68	0.19
Jessore region	Dummy (1 if member, 0 otherwise)	0.26	0.44
Comilla region	Dummy (1 if member, 0 otherwise)	0.31	

[9] The Herfindahl index is an index of crop concentration. Therefore, a negative sign of the coefficient on the explanatory variable implies positive relationship with diversity and vice-versa.

Table 5. Summary Statistics of the Variables Used in the Models (Continued)

Variables	Unit of Measurement	Mean	Standard Deviation
Diversity indices			
Species concentration (Herfindahl)	Number	0.60	0.46
Species richness (Margalef)	Number	0.30	0.27
Species evenness (Shannon)	Number	0.67	0.51
Number of observations		406	

Table 6. Economic Determinants of Crop Diversity on Farms

Variables	Tobit Model of Richness Index		Tobit Model of Evenness Index		OLS Model of Concentration Index	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	1.4006***	4.22	3.0168***	5.18	-0.4805**	-1.97
Price variables						
Fertilizer price	-0.0477***	-4.18	-0.0872***	-4.35	0.0379***	4.47
Animal power price	-0.0031***	-2.81	-0.0056***	-2.86	0.0024***	2.87
Labor wage	0.0018	0.63	0.0044	0.91	-0.0026	-1.29
Pesticide price	0.0001	0.12	-0.0001	-0.08	0.0001	0.21
Modern rice price	-0.0351***	-6.32	-0.0819***	-8.40	0.0394***	9.85
Jute price	-0.0209	-1.41	-0.0411	-1.57	0.0187	1.63
Cash crop price (overall)	0.0139**	2.42	0.0076	0.76	-0.0006	-0.13
Socio-economic characteristics						
Amount of land cultivated	0.0643***	3.53	0.1345***	4.20	-0.0444***	-3.23
Farming experience	0.0017	1.59	0.0034*	1.78	-0.0014*	-1.72
Education of farmer	0.0110***	2.88	0.0161**	2.40	-0.0065**	-2.27
Family size	-0.0017	-0.26	0.0039	0.34	-0.0029	-0.61
Ratio of working male member	-0.0343	-0.35	-0.1163	-0.67	0.0585	0.81
Value of livestock owned	0.0036*	1.85	0.0066*	1.92	-0.0021	-1.40
Other farm capital asset	-0.0019	-1.39	-0.0050**	-2.12	0.0022**	2.18
Amount of loan taken	0.0002	0.16	0.0020	0.95	-0.0011	-1.22
Tenurial status	-0.1325**	-2.42	-0.2781***	-2.91	0.1258***	3.22
Irrigation	-0.2399***	-4.84	-0.4451***	-5.11	0.1861***	5.13
Extension contact	0.0476	1.11	0.0972	1.29	-0.0368	-1.14
Membership in NGOs	0.0599*	1.92	0.0814	1.49	-0.0237	-1.02
Soil fertility index	-0.0804	-0.71	-0.2034	-1.03	0.0815	0.98
Infrastructure index	-0.0049***	-3.53	-0.0093***	-3.81	0.0039***	3.98
Jessore region	0.0455	0.78	0.1029	1.00	-0.0340	-0.80
Comilla region	-0.0381	-0.61	-0.1620	-1.49	0.0736*	1.65
Model diagnostics						
Log likelihood	-97.31		-273.55		-97.41	
$\chi^2_{(23, 0.99)}$	232.53***		274.53***		--	
$F_{(23, 382)}$	--		--		16.61***	
Pseudo-R^2/Adjusted R^2	0.54		0.33		0.47	
Uncensored observations	299		299		406	
Left censored observations	107		107		--	
Number of observations	406		406		406	

Notes: *** = significant at 1 percent level (p<0.01); ** = significant at 5 percent level (p<0.05); * = significant at 10 percent level (p<0.10).

Table 6 presents the parameter estimates of all three regression models. Prior to describing the results, we discuss estimation diagnostics briefly. A total of 107 observations were censored on the left at 0, implying that these are the specialized farms. The presented models were able to explain 54 and 33 percent of the variations in crop diversity as reflected by pseudo-R^2 in crop richness and evenness models and 47 percent in the crop concentration model reflected by adjusted-R^2 value, respectively. Coefficients on 11 out of a total of 23 variables were significantly different from zero at 10 percent level at least in each of the models, indicating that the variables included in the models to explain crop diversity were correctly justified. The signs of the coefficients mirror each other in all three models indicating robustness of the results, although their magnitudes differ slightly across models[9]. Coefficients of the Tobit models cannot reveal the magnitude of the effect directly. Therefore, their marginal effects[10] were estimated and presented in table 7.

Table 7. Marginal Effects of the Economics Determinants of Crop Diversity on Farms

Variables	Tobit Model of Richness Index		Tobit Model of Evenness Index		OLS Model of Concentration Index	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	1.1633***	4.20	2.7194***	5.18	-0.4805**	-1.97
Price variables						
Fertilizer price	-0.0398***	-4.18	-0.0785***	-4.34	0.0379***	4.47
Animal power price	-0.0026***	-2.80	-0.0051***	-2.86	0.0024***	2.87
Labor wage	0.0015	0.63	0.0040	0.91	-0.0026	-1.29
Pesticide price	0.0009	0.12	-0.0001	-0.08	0.0001	0.21
Modern rice price	-0.0292***	-6.37	-0.0741***	-8.50	0.0394***	9.85
Jute price	-0.0175	-1.42	-0.0371	-1.57	0.0187	1.63
Cash crop price (overall)	0.0115**	2.40	0.0067	0.74	-0.0006	-0.13
Socio-economic characteristics						
Amount of land cultivated	0.0536***	3.53	0.1214***	4.20	-0.0444***	-3.23
Farming experience	0.0015	1.61	0.0031*	1.79	-0.0014*	-1.72
Education of farmer	0.0092***	2.90	0.0145**	2.40	-0.0065**	-2.27
Family size	-0.0014	-0.25	0.0036	0.35	-0.0029	-0.61
Ratio of working male member	-0.0288	-0.35	-0.1054	-0.67	0.0585	0.81
Value of livestock owned	0.0031*	1.86	0.0060*	1.93	-0.0021	-1.40
Other farm capital asset	-0.0016	-1.40	-0.0045**	-2.13	0.0022**	2.18
Amount of loan taken	0.0002	0.16	0.0018	0.94	-0.0011	-1.22
Tenurial status	-0.1101**	-2.41	-0.2513***	-2.91	0.1258***	3.22
Irrigation	-0.1997***	-4.84	-0.4026***	-5.14	0.1861***	5.13
Extension contact	0.0399	1.11	0.0873	1.28	-0.0368	-1.14
Membership in NGOs	0.0503*	1.94	0.0734	1.49	-0.0237	-1.02
Soil fertility index	-0.0655	-0.69	-0.1820	-1.02	0.0815	0.98
Infrastructure index	-0.0041***	-3.52	-0.0084***	-3.81	0.0039***	3.98
Jessore region	0.0381	0.78	0.0918	0.99	-0.0340	-0.80
Comilla region	-0.0313	-0.61	-0.1460	-1.49	0.0736*	1.65

Notes: *** = significant at 1 percent level ($p<0.01$); ** = significant at 5 percent level ($p<0.05$); * = significant at 10 percent level ($p<0.10$). Computing marginal effects of dummy variables in censored regression models are highly complicated. However, Greene (2007) claims that the default computational method of marginal effects (i.e., coefficient * probability of non-censored observations) for the dummy variables in NLOGIT-4 software provides a remarkably close guesstimate of the true effect (ESI, 2007).

The likelihood of crop diversity increases significantly by a decline in the prices of fertilizers and animal power services. For example, a one percent decline in the price of fertilizers will increase crop richness by 4 percent, evenness by 8 percent and diversity by

[10] Since, OLS model is used to estimate the parameters of the crop concentration model, the regression coefficient essentially depicts the marginal effects. Therefore, the regression result from table 6 was reproduced for this model in table 7.

5 percent, respectively. This is expected because some crops, particularly vegetables and/or potatoes, require large amount of fertilizers and, therefore, a decline in fertilizer prices would induce the switch from conventional rice farming. Similarly, a reduction in the price of moder rice will significantly promote crop diversity. Alternatively, a rise in rice price will promote modern rice monoculture. Also, an increase in the cash crop price will significantly increase crop diversity as expected, although the magnitude of influence is quite low, about 1 percent.

Farm size is positively related to promoting crop diversity, as expected. The implication is that, as farm size increases, farmers are able to choose a diversified portfolio of crops which satisfies both consumption purposes as well as generate surpluses for the market by growing high value non-cereal and/or cash crops. Benin et al. (2004) also found significant relationship of farm size with crop diversity in Ethiopian highlands. In addition to farm size, livestock ownership also positively influences farmers to diversify, as expected. Benin et al. (2004) also found a similar significant relationship of oxen ownership with crop diversity. On the other hand, farm capital asset promotes specialization towards modern rice monoculture, although the magnitude of influence is very small.

Availability of irrigation is the single most important determinant of specialization towards modern rice monoculture, as expected (see the crop concentration model). This result corroborate with the finding of Hossain et al. (1990), who noted that access to irrigation is a major determinant of modern rice technology adoption in Bangladesh. In other words, cropping diversity is significantly higher in areas with no irrigation, which corroborates with the conclusions of Mahmud, Rahman and Zohir (1994) and Morris, Chowdhury and Meisner (1996). In fact, wheat provides highest returns in non-irrigated zones and in areas that are unsuitable for *Boro* rice (Morris, Chowdhury and Meisner 1996). Benin et al. (2004) reported similar effect but its influence was not significantly different from zero.

Owner operators are more likely to diversify their farms as compared to the tenants, who tend to specialize towards modern rice monoculture, which corroborates with the finding of Hossain et al. (1990). This is because tenurial system in Bangladesh is largely based on arrangements related to rice production. In the most common tenurial arrangement practiced in Bangladesh, the landlord receives one-third of the crop output share (mostly rice). The incidence of input cost share by the landlord varies across regions. Areas where such cost is shared (usually on a 50-50 basis), the arrangement is based on sharing of relatively scarce input, e.g., fertilizer, irrigation and/or animal power hire costs (Rahman 1998). Therefore, existing tenurial arrangement seems to work well when the tenant grows rice. However, when a diversified cropping system is adopted, it may exert a discouraging effect, because the amount to be received as output share cannot be clearly estimated *a priori*.

The education level of farmer and farming experience, both have a significant positive relationship with crop diversity, as expected. As mentioned earlier, the ability to process information increases with education as well as experience. Therefore, educated and/or experienced farmers choose to adopt a diversified cropping system in order to take advantage of all the potential benefits arising from making such a choice, e.g., high returns for a particular crop, low overall resource cost, and/or spreading of scarce family labor evenly over a crop year.

Farm households with membership in development NGOs are also likely to diversify. This is expected because most development NGOs in the rural regions of Bangladesh promote vegetable production by involving female clientele of the farming households, popularly known as kitchen gardens.

The likelihood of adopting a diversified cropping system is significantly higher in regions with developed infrastructure[11]. The influence of developed infrastructure in adopting a diversified cropping system is obvious. For example, vegetable production provides a significantly higher return (Rahman 1998), but is highly perishable and needs to be marketed immediately after harvest. The prospect of doing so increases only in regions with developed infrastructure.

Farmers in Comilla region has the lowest crop diversity and tends to specialize towards modern rice monoculture, which is also evident in table 3. This is because, Comilla region is a densely populated region with relatively small farm size and all technological innovations relating to ‘Green Revolution’ have been initiated in this region through BARD (the Bangladesh Academy of Rural Development) located in the central district of Comilla.

Discussions

Results of this study clearly reveal that a host of price and non-price factors influence farmers’ decision to diversify. When a farm diversifies into a variety of crops, the farmer uses the opportunity to select enterprises that complement each other, given the nature of seasonality in demand for various inputs. The cropping system in Bangladesh is largely influenced by access to water. The cropping pattern can be broadly classified into cropping under rainfed and irrigated conditions, which again vary according to the degree of seasonal flooding. As mentioned earlier, although many non-cereals are more profitable than producing modern rice, their expansion has stagnated due to the incompatibility of the existing modern irrigation systems (Mahmud, Rahman and Zohir 1994). In general, the proportion of non-cereal crops is lower under irrigated conditions as compared to rainfed conditions (Mahmud, Rahman and Zohir 1994), which is also demonstrated in this study. For example, crop diversity is significantly lower in the Comilla region when compared with Jamalpur and Jessore regions. This is because some of our sampled households in Comilla region were located within the catchment area of the Meghna-Dhonagoda Flood Control, Drainage and Irrigation (FCD/I) project, where modern rice monoculture is the norm because of the assured availability of surface water for irrigation at a cheap rate (Rahman 1998). Also, as mentioned above, ‘Green Revolution’ towards modern rice monoculture is also initiated in Comilla region, which later expanded to every corner of Bangladesh.

An important issue that limits the scope to expand non-cereals is the existence of the price risk associated with uncertainties in marketing, particularly for perishable crops, such as vegetables. In fact, annual variability in harvest prices is as high as 15–25 percent for most fruits and vegetables (including potatoes) and 20–40 percent for spices as compared to only 5–6 percent for cereals (Mahmud, Rahman and Zohir 1994). This perhaps explains the decline in the area under spices between the census years (Table 1). Mahmud, Rahman and Zohir (1994) further noted that the price shock is most severe at the level of primary markets during harvest seasons. Delgado (1995) stressed the need for addressing marketing issues and constraints as a priority option to promote agricultural diversification in sub-Saharan African regions. This is because in the absence of improved markets, the agricultural sector is likely to suffer from demand constraints as well as a weak supply response, thereby, affecting growth. One way to lower the price risk is through improvements in marketing, which in turn depends on the development of the rural infrastructure.

Our results clearly show that prices of modern rice and cash crops have significant bearing on farmers' decision to diversify. Also, developed rural infrastructure significantly promotes adoption of a diversified cropping system. Infrastructure development in turn may also open up opportunities for marketing, storage and resource supplies, which complements crop diversification. For example, Ahmed and Hossain (1990) concluded that farms in villages with relatively developed infrastructure use relatively greater amounts of fertilizer and market a higher percentage of their agricultural products in Bangladesh. Evenson (1986) noted a strong relationship between roads and increased agricultural production in the Philippines. He claimed that a 10 percent increase in roads would lead to a 3 percent increase in production in the Philippines. Ahmed and Donovan (1992) concluded that "the degree of infrastructural development is in reality the critical factor determining the success of market-oriented sectoral and macroeconomic policies in the developing world" (p39).

Also, it should be noted that the non-cereals produced by most farmers comprised largely traditional varieties, which are low yielding. Strategy to improve varieties of non-cereals, therefore, provides further potential to improve productivity gains from diversification. Conventionally, the R&D activities in Bangladesh are largely concentrated on developing modern rice varieties to the neglect of most other crops. Among the non-cereals, modern technology is only well established in potato cultivation (Mahmud, Rahman and Zohir 1994). The Bangladesh Agricultural Research Institute (BARI) is entrusted with the responsibility of developing modern varieties of all cereal and non-cereal crops except rice and jute. To date, a total of 131 improved varieties of various cereal and non-cereal crops have been developed and released by BARI (Hossain et al. 2006). The thrust in developing and releasing improved varieties by BARI actually gained momentum from mid-1990s, a complementary effort to government's emphasis on promoting crop diversification in its Fifth Five Year Plan document (1997–2002). However, there is a need to examine the impact of these new releases on farmers' portfolios of crop choices at the farm level, because the technical and socio-economic constraints on the diffusion of these technologies remain unexplored and less understood (Mahmud, Rahman and Zohir 1994).

Farmers' wealth status in the form of farm size and livestock ownership also has significant influence on crop diversity. Therefore, shrinking of farm size that we observed over the years is likely to adversely affect crop diversity. However, improvement in the livestock sector in order to promote livestock ownership by individual farmers could partially offset such a detrimental effect of shrinking farm sizes on crop diversity.

CONCLUSION

The aim of this study was to identify the economic determinants of crop diversity on farms in rural Bangladesh. The computed value of diversity indices of species concentration (Herfindahl), richness (Margalef) and evenness (Shannon) confirm that

[11] The index reflects the underdevelopment of infrastructure, and therefore, a negative sign indicates positive effect on the dependent variable. In other words, the positive sign on the coefficient implies positive relationship towards crop diversification.

farming system in Bangladesh is still relatively diverse despite four decades of thrust in the diffusion of a 'Green Revolution' technology package aimed at promoting modern rice monoculture. Results reveal that a host of price and non-price factors significantly influence farmers' decision to diversify. Likelihood of diversification increases with a fall in the prices of fertilizers, animal power services and modern rice and a rise in the price of cash crops. Crop diversification is positively influenced by farm size, livestock ownership, farming experience, education, membership in NGOs, regions with developed infrastructure and unavailability of irrigation. Also, diversification is significantly higher among owner operators.

Policy Implications

The key policy implications that emerge from this study are that crop diversification can be promoted significantly by investing in rural infrastructural development, education targeted at the farming population, livestock sector, and supporting NGOs working in the rural areas. Also, price policies aimed at reducing fertilizer and animal power prices and increasing cash crop prices would significantly promote crop diversity. A diversified cropping system is likely to have a positive impact on agricultural sustainability, as it is clear from the literature that the Green Revolution technology based on modern rice monoculture is unsustainable in the long-run. Therefore, the present thrust at the planning level to promote crop diversification is a step in the right direction. Furthermore, appropriate land reform policies that focus on delegating land ownership to landless, marginal and small farmers as well as improvements in existing tenurial system, which is now biased towards favoring modern rice monoculture, would boost the number of owner operators, who are the most likely adopters of a diversified cropping system. Another area of intervention is in the livestock sector, which is a crucial input in the farming industry. The aim would be to promote livestock ownership by individual farmers which have a significant positive influence on crop diversity.

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PRICING-TO-MARKET AND EXCHANGE RATE PASS-THROUGH IN EUROPEAN IMPORT MARKETS: THE CASE OF FISH FROM LAKE VICTORIA

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ABSTRACT

This study addressed the pricing-to-market behavior and the completeness of exchange rate pass-through in the EU market for Lake Victoria (Kenya, Tanzania and Uganda) fish. Results suggest that European importers priced-to-market when purchasing fresh fillets from Kenya and frozen fillets from Uganda. The estimated exchange rate effect for fresh fillet imports indicated that 50% of currency devaluations are passed through to import prices denominated in the exporting country's currency (shillings). Only 30% of currency devaluations are passed through to the import prices of frozen fillets denominated in shillings. Overall, results suggest that EU importers were able to adjust import prices downward when currency values declined in Kenya, Tanzania or Uganda. This suggests that Lake Victoria fish exporters do not fully benefit from exchange rate policies to encourage exports.

Key words: Lake Victoria, EU, fish, pricing-to-market, exchange rate pass-through
JEL Classification: Q17, F13

1. INTRODUCTION

The noncompetitive pricing behavior of large exporters has been extensively studied. Past research that addressed exporter market power have utilized the pricing-to-market (PTM) hypothesis (Krugman 1987) which states that a large exporter can price discriminate across destination markets given changes in bilateral exchange rates (Miljkovic 1999). Since Knetter (1989) developed an empirical methodology for testing PTM behavior, a number of studies have followed which include Pick and Park (1991), and Yumkella, Unnevehr and Garcia (1994). The PTM literature is primarily comprised of exporter oriented studies, and as noted

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by Devadoss and Song (2006), market imperfections due to oligopsony (importer) power have received far less attention in the new trade theory literature.

Karim (2005) notes that there have been a large number of empirical studies considering the extent to which changes in exchange rates are passed through to import prices. Exchange rate pass-through (EPT) is the percentage change in local currency import prices following a 1% change in the bilateral exchange rate between an importing and exporting country. A one-to-one response of import prices to exchange rate changes is referred to as complete EPT while a less than one-to-one response is referred to as partial or incomplete EPT (Rakotoarisoa and Shapouri 2001). Empirical studies of exchange rate pass-through (EPT) have largely focused on the extent to which exchange rate movements are transmitted to the pricing of traded goods versus absorbed in the profit margins of firms. Most studies have focused on the industrialized countries. EPT research for developing countries has been lacking (Karim 2005).

The purpose of this paper is to contribute to the analysis of importer PTM behavior and EPT in developing countries. Developing countries have common characteristics in that they tend to be price takers in international markets and are dependent upon industrialized countries for export disappearance where exports are typically concentrated in a single destination country or market. This geographic concentration of exports can have negative economic consequences. Exports are more vulnerable to fluctuations in a single country or region's import demand and economic conditions, and exports are particularly vulnerable to protectionist policies (McGowan 1976; Moss and Ravenhill 1989). Moreover, the concentration of exports could give rise to importer price discrimination resulting in relatively lower prices for exports (Rakotoarisoa and Shapouri 2001).

The primary objective of this study is to test the PTM hypothesis and the completeness of EPT in the EU market for Lake Victoria fish. The fish sector is of particular importance because it is considered a "nontraditional" agricultural sector different from traditional sectors such as coffee, cotton and tea. Unlike traditional agricultural exports which are mostly raw commodities, a significant amount of domestic value added occurs in the nontraditional sectors creating employment for poor rural households. Nontraditional exports are also considered to be instrumental in restoring balance of payments, increasing export earnings and reducing export revenue variability in the Lake Victoria region, and are important to overall economic growth (Dijkstra 2001). Increased investments in nontraditional exports have resulted in Lake Victoria fish being a major source of foreign exchange for riparian countries, particularly for Uganda where fish is the second largest export by value (Abila 2000; Uganda Export Promotion Board 2005).

Following Knetter (1989), Rakotoarisoa and Shapouri (2001) developed a method for testing the PTM hypothesis for large importing countries. Aside from being the fist study to analyze PTM behavior in the context of a large importer, there study also highlighted a common phenomenon with certain agricultural exports from developing countries which is the tendency for a single industrialized country to account for a significant percent of export disappearance. This is particularly true in the EU market for Lake Victoria fish where, in 2005, the EU accounted for 98%, 90% and 65% of all fresh fillet exports from Kenya, Uganda and Tanzania, respectively, and imported 60%, 35% and 10% of all frozen fillet exports from Uganda, Kenya, and Tanzania, respectively (UNCOMTRADE 2006). Given that the EU is the principal market for Lake Victoria fish, it is not unlikely that the concentration of fish exports has resulted in importer price discrimination.

PTM behavior on the part of EU importers and the completeness of EPT is of particular importance to the fish exporting sectors in Kenya, Tanzania and Uganda with even broader implications for the macroeconomy. Theoretically, a shilling devaluation should results in higher exports prices (in shillings), increased fish exports and increased export revenue (Koo and Kennedy 2005, pp. 218-220). However, with incomplete or partial EPT, exporters do not fully benefit from currency devaluations. This has important implications for the effect of monetary policy on domestic industries. For instance, in an effort to increase export revenue, the Structural Adjustment Programs (SAPs) of the World Bank and International Monetary Fund mandated currency devaluations for developing countries as a precondition for receiving financial support (Wobst 2001; Welch and Oringer 1998). PTM behavior and partial EPT could diminish the effects of such policies or render them ineffective (Mumtaz, Oomen and Wang 2005).

The remainder of this paper is organized as follows. The following section gives a brief overview of the fish exporting industries around Lake Victoria and their relationship to the EU. Exchange rate movements from 2000-2006 and their impact on import prices are also discussed in this section. The third section presents a brief overview of the conceptual model. The fourth section gives an overview of the data and estimation methods. The fifth section presents the empirical results. In the final section we summarize the results and give closing remarks.

2. BACKGROUND

Lake Victoria is the second biggest freshwater lake in the world. At 69,000 km^2, the lake is the same size as Ireland and is shared between three countries: Tanzania (which possesses 49%), Uganda (45%) and Kenya (6%) (Bokea and Ikiara 2000). Fish exports from Lake Victoria and neighboring waters have been an important source of revenue for riparian countries. In 2004, total fish exports for the region were 94 million kilograms (kg), valued at $256 million dollars. Exports for each country were 46, 31 and 17 million kg for Tanzania, Uganda and Kenya respectively. From 2000 to 2005, the fish exporting sectors in the three countries grew by 24% (Kenya), 11% (Tanzania) and 89% (Uganda) annually (UNCOMTRADE, 2006).

The development of the fish exporting sectors around Lake Victoria is relatively recent. Of the three countries, Kenya was the first to establish processing plants dedicated to exports. Uganda and Tanzania soon followed (Dijkstra 2001). Prior to the late 1980s, Lake Victoria fisheries provided for local populations for the most part. In the decades that followed, over exploitation of fish stocks in industrialized countries increased dependence on fish stocks in the Lake Victoria region. Consequently, the number of fish processing plants along Lake Victoria increased significantly. The first processing plant for the export market was built in late 1980. By 2000, 35 factories had been constructed, of which 25 were established after 1990 (Reynolds and Greboval 1988; Abila 2000).

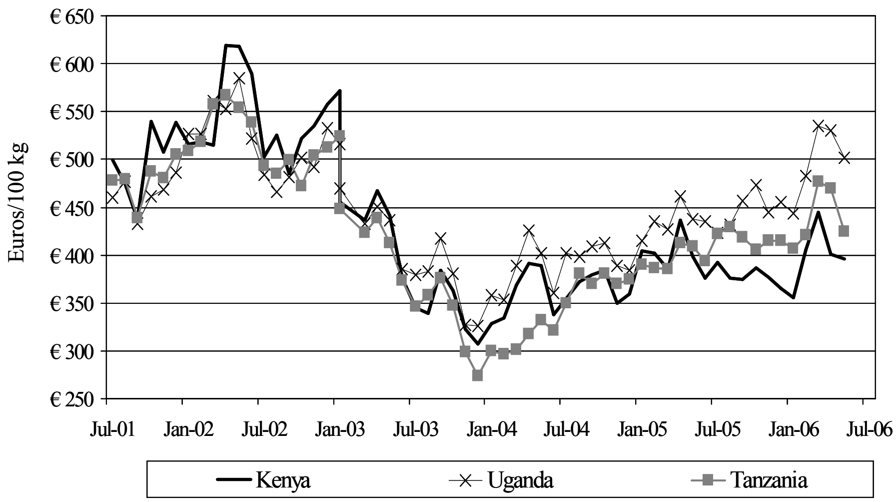
The primary fish export from Lake Victoria is the Nile perch in fillet form. Introduced in the early 1960s, the Nile perch has been the subject of controversy due to the 200 indigenous fish species becoming extinct as a result of the Nile perch's predatory nature. Ecological impacts aside, the introduction of the Nile perch resulted in unprecedented catches, stimulated commercial fisheries and increased socio-economic benefits for the people in the riparian states (Export Processing Zone Authority 2005; Pringle 2005; Ntiba, Kudoja and Mukasa 2001; Dijkstra 2001). As noted by Abila (2000), the development of the fish processing sectors around Lake Victoria was a direct result of the extensive growth in Nile perch demand in developed countries.

The EU's dominance in Lake Victoria's fish trade was made apparent by three successive import bans imposed on fish from the region. The bans were imposed from February 1997 through June 1998 and March 1999 through August 2000. The first and second bans were due to the Spanish Veterinary Authority detecting salmonella microbes in Lake Victoria fish. The third ban was the result of fisherman using pesticides and chemicals to intoxicate fish to increase catches (Dijkstra 2001). Much of the capital in the fisheries sector went unused during this period causing prices and industry output to decline significantly (Marriott, Dillon and Hannah 2004). During this period, fresh fillet exports reached an annual low of 5,613 tons. After the ban was lifted, fresh exports averaged 33,500 tons annually (2001-2003). Frozen fillets reached a low of 2,800 tons during this period and have averaged 8,000 tons since (Josupeit 2005).

European import prices denominated in euros (by exporting country) are presented in Figures 1 and 2. Overall, import prices for fresh and frozen fillets are highly correlated between the three exporting countries. This should be the case given the geographic proximity of the three countries and the cross-country homogeneity of their fish exports. Given this homogeneity, we would also expect cross-country price differences to be minimal or nonexistent. However, with PTM behavior it is possible for import prices (in euros) to differ across countries given changes in bilateral exchange rates even when products are relatively homogeneous across countries (Miljkovic 1999).

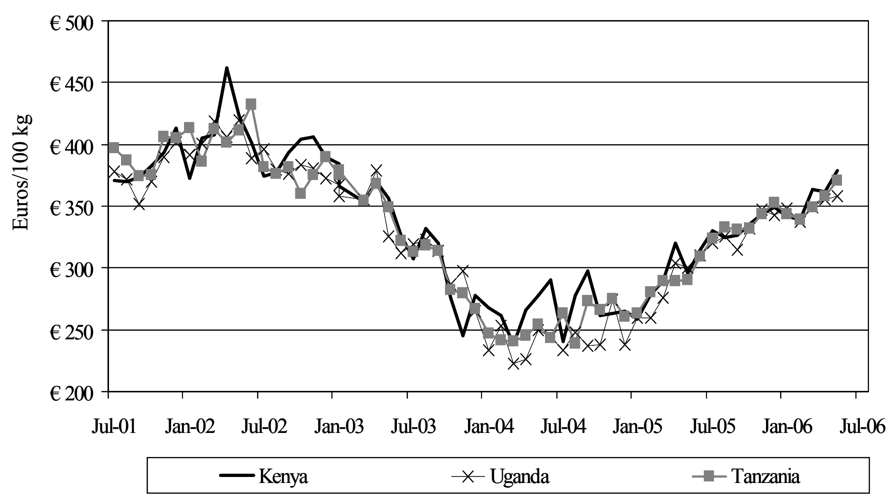
Cross-country price differences were found in the fresh fillet market. From 2001 through 2003, the difference in fresh fillet import prices ranged from €0 to about €50. Significant price differences occurred in 2004. In April 2004, the price of Tanzania's fillets (€318) was over €100 lower than Uganda's price (€426) and €73 lower than Kenya's price (€391). In 2005 and 2006, Kenya's price was significantly lower than Uganda and Tanzania. Throughout 2006, the price of fresh fillets from Uganda averaged €500. Tanzania's price was €40 lower on average, and Kenya's price was about €100 lower. Frozen fillet import prices were relatively the same across the three exporting countries, particularly in 2005 and 2006 where the difference in import prices averaged less than €20.

Indexes of the euro per shilling exchange rate for Kenya, Tanzania and Uganda (January 2000-May 2006) are presented in Figure 3. To account for the strength of the euro relative to other vehicle currencies, an index of the U.S. dollar per euro exchange rate is also included in the figure. The year 2000 is the base year for all indexes (2000 average = 100). Lake Victoria currency values relative to the euro were significantly related to the strength of the euro relative to the U.S. dollar. Simple regressions showed that 96% of the variation in the Kenyan shilling was explained by the value of the euro relative to the dollar. The dollar price of the euro also explained 91% and 90% percent of the variation in the Tanzanian shilling and Ugandan shilling, respectively.



Source: Eurostats

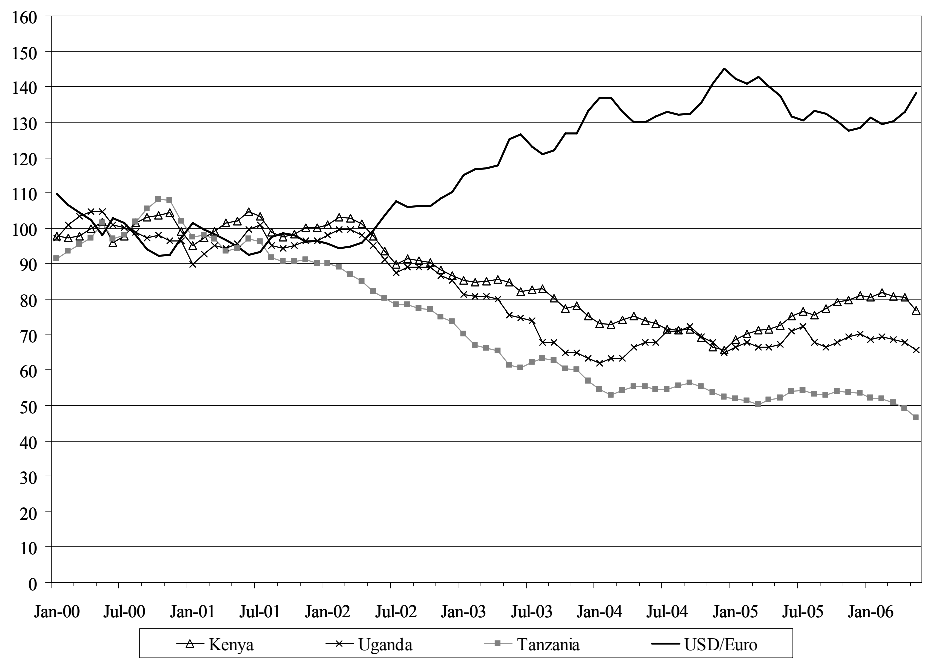
Figure 1. EU import prices for Lake Victoria fresh fillets: July 2001-May 2006



Source: Eurostats

Figure 2. EU import prices for Lake Victoria frozen fillets: July 2001-May 2006

From January 2000 to early 2002, each country's currency maintained its value relative to euro. Starting in 2002, the euro appreciated against the dollar and consequently, the Kenyan, Tanzanian and Ugandan shillings all decreased in value relative to the euro. This continued until 2005. Although each country was impacted by the relatively strong euro, the Tanzanian shilling lost more value when compare to the other currencies. In 2005, the dollars per euro exchange rate began to decrease and the Kenyan shilling became relatively stronger. The Ugandan and Tanzanian shillings remained relatively unchanged on average during this period.



Source: OANDA Corporation and freelunch.com

Figure 3. Euro per Shilling Exchange Rate Index by Country and the $US per Euro exchange rate index: January 2000-May 2006 (2000 average =100)

A comparison of the imports prices in Figures 1 and 2 and the exchanges rate indexes in Figure 3 show the possible relationship between the exchange rate and import prices denominated in euros. The dollar per euro exchanged rate increased by 40% during the period 2002-2004. This resulted in a significant depreciation in the shilling(s) relative to the euro. Fillet import prices (in euros) decreased in value during this period more so than any other period. When the euro increased in value by 40%, the price of fresh and frozen fillets fell by 41% and 38% respectively during this period.

With complete EPT it can be easily shown that import prices denominated in euros should be invariant to changes in the exchange rate. The law of one price states that prices in euros $p_{€}$ should equal to prices in shillings p_{sh} times the euro per shilling exchange rate $e_{€/sh}$. In terms of elasticities this relationship can be written as

$$\frac{d \log p_{€}}{d \log e} = 1 + \frac{d \log p_{Sh}}{d \log e}. \tag{1}$$

With complete EPT the second term on the right hand side of equation (1) is equal to -1 and equation (1) is equal to 0. Therefore complete EPT implies that exchange rate changes are fully pass through to prices denominated in shillings and import prices denominated in euros should remain unchanged. The observed relationship between exchange rates and import prices in the previous figures may be an indication of partial or incomplete EPT in these markets.

3. CONCEPTUAL MODEL

The PTM hypothesis offers evidence on the role of market structure in international trade. Following Knetter (1989), Rakotoarisoa and Shapouri (2001) developed a method for testing the PTM hypothesis for large importing countries. Their study investigated whether U.S. importers of vanilla beans offered different prices to exporters in developing countries. Similar to the U.S. market for vanilla bean imports, the EU dominates fish trade with the Lake Victoria region which is comprise of developing countries. Thus, we use the empirical model in Rakotoarisoa and Shapouri (2001) for our analysis which is presented in this section.

Let EU fillet imports from Kenya, Uganda and Tanzania be represented by x_1, x_2, and x_3 respectively, and let the inputs required for processing and importing be represented by the vector **Z**. **Z** includes labor, capital, and other value-added inputs. The production function for the importer can be specified as $f(x_1, x_2, x_3, \mathbf{Z})$ and the profit maximization problem (PMP) is

$$\text{Max } \Pi = p_t^d f(x_{1t}, x_{2t}, x_{3t}, \mathbf{Z}_t) - \sum_{i=1}^{3} p_{it}^m x_{it} - \mathbf{w}_t^{'} \mathbf{Z}_t \,. \tag{2}$$

p^d and p^m are the domestic and import prices respectively, and **w** is a vector of input prices. If the importer is sufficiently large, import prices are not exogenous and the first order necessary condition is

$$p_t^d f_{xit} = p_{it}^m \left[1 + \frac{1}{\varepsilon_{it}} \right] \forall i \,;\; \varepsilon_{it} = (\partial x_{it} / \partial\, p_{it}^m)(p_{it}^m / x_{it}) \,. \tag{3}$$

ε_{it} is the export supply elasticity for exporting country i. For a small importer $\varepsilon_{it} = \infty$, and the import price p_i^m is equal to the marginal value product, $p^d f_{xi}$. Therefore, the term in brackets is the import price markdown due to monopsony power. Solving equation (2) for p_i^m, the import price of fish from country i can be written as

$$p_{it}^m = p_t^d (MP_x)_{it} \left[\frac{\varepsilon_{it}}{\varepsilon_{it} + 1} \right]. \tag{4}$$

$(MP_x)_{it} = f_{xit}$, which is the marginal product of x.

Taking the natural log of equation (4) and including an exchange rate term, Rakotoarisoa and Shapouri (2001) proposed the following fixed-effects econometric specification for testing PTM and EPT for a large importer:

$$\ln p_{it}^m = \theta_t + \lambda_i + \alpha \ln p_t^d + \beta_i \ln e_{it} + u_{it} \,. \tag{5}$$

e is the exchange rate and u is the error term. θ_t and λ_i are the time and country effects, respectively. The parameter θ_t captures the time effects which can measure changes in the quality of imports or increases in the marginal product overtime. λ_i captures the country effect which measures the component of the markdown factor that differs across exporting sources. The coefficient α indicates the change in the benefit margin and is also the inverse of the pooled elasticity of output price with respect to import price. β_i measures the impact of exchange rates on optimal monopsony markdowns.

Abbott, Patterson, and Reca (1993) indicate that the parameters in equation (4) provide the basis for testing PTM behavior when an imported product is not differentiated across source countries. This issue was further investigated by Lavoie and Lui (2007) where they note that past findings of PTM that are often attributed to price discrimination might alternatively be due to product differentiation, particularly when aggregate units values are used as proxies for prices. Given that the primary fish export from this region is Nile perch which is relatively homogeneous across riparian countries, and given the geographic proximity of the three exporting countries, country-specific product differentiation should be minimal or nonexistent in this instance. Therefore, the PTM behavior observed in the EU market for fresh and frozen fillets should be the result of price discrimination and not product differentiation.

For a small importer, prices are the same across all destinations (no PTM) and changes in the bilateral exchange rate do not affect bilateral import prices (complete EPT). This is the case when $\lambda_i = 0$ and $\beta_i = 0$. The lack of market power does not allow the importer to affect import prices when the exchange rate varies, or to price discriminate among sources. When $\lambda_i = 0$ and $\beta_i = 0$, equation (5) states the first order condition for a perfectly competitive industry which is that import prices equal the marginal value product.

It is possible for EPT to be complete in the presence of an imperfectly competitive import market. This is the case when $\lambda_i \neq 0$ and $\beta_i = 0$. Although exchange rate movements have no direct impact on the export supply elasticity and do not affect import prices, the supply elasticity perceived by importers may be constant but may differ across exporting countries allowing for price discrimination. $\lambda_i \neq 0$ and $\beta_i \neq 0$ for the ith country indicate price discrimination and incomplete EPT (Rakotoarisoa and Shapouri, 2001).

If the export supply elasticities vary with the exchange rate, then the optimal markdowns below marginal import cost will also vary with the exchange rate. This implies that $\beta_i \neq 0$. The sign of β_i reveals the way markdowns respond to exchange rate changes. A negative sign indicates that importers adjust prices downward when the exporter's currency is devalued and that exchange rate changes are not fully reflected in import prices denominated in the exporter's currency. Therefore, the percentage of devaluations pass through to import prices denominated in the exporter's currency can be calculated as $1-|\beta_i|$.

4. DATA AND ESTIMATION METHODS

In this study we considered the three exporting countries in the Lake Victoria region (Kenya, Uganda, and Tanzania) and one importing country (region) the EU. The products/markets were frozen and fresh fillets. The data used in the analysis were monthly and covered the period July 2001 through May 2006 for frozen fillets and September 2000 through May 2006 for fresh fillets. Imported quantities were the CN8 commodity classifications "fresh or chilled fillets of freshwater" and "frozen fillets of freshwater" (not elsewhere specified). Per-unit import values (total value ÷ total quantity) were used as proxies for import prices. Country-specific import quantities and values were obtained from Eurostat (Statistical Office of the European Communities). Monthly exchange rate data were provided by the OANDA Corporation.

Josupeit (2005) notes that the majority of Nile perch consumed in the EU is imported via Belgium or the Netherlands. This suggests that re-export values in Belgium and the Netherlands could reflect the wholesale value of Nile perch in the EU. Given that Belgium and the Netherlands account for a significant percent of intra-EU exports in the two CN8 commodity classifications encompassing Nile perch, we use the intra-EU per-unit export value (also provided by Eurostat) as a proxy for the domestic price. While this is somewhat different from Rakotoarisoa and Shapouri (2001), their study did not involve a re-exported product.

In equation (5) $i \in$(Kenya, Tanzania, and Uganda); ln p_i^m is the natural log of EU import prices of frozen or fresh fillets in euros per 100 kg; ln p^d is the natural log of EU export prices of fresh or frozen fillets in euros per 100kg; and ln e_{it} is the natural log of the bilateral exchange rate between the EU and the ith country where e is defined as shillings per euro.

A procedure for estimating equation (5) is the Park’s method which is available in SAS 9.1 (TSCSREG procedure). The Park’s method assumes that the random errors are AR(1) with contemporaneous correlation between cross sections and a different AR parameter for each cross section. However, Park’s method has been criticized for this assumption (Beck and Katz, 1995). Instead, Beck and Katz suggest a single pooled AR parameter for all cross sections. Yet, given the nature of the problem with different countries exporting the same product to a single country, there may be common shocks affecting the import price for each of the exporting countries, e.g. macroeconomic and microeconomic factors that would impact Nile perch demand in the EU thus impacting all three countries. This is to a degree reflected in the import price movements in Figures 1 and 2. In addition, these common shocks may cause the error term in equation (5) to be non-stationary. The existence of common shocks of non-stationarity leads to cointegrated series. Bai, Kao, and Ng (2007, p.1-2) notes that in a panel data model specified by $y_{it} = x'_{it}\beta + e_{it}$ where y_{it} and x_{it} are I(1) processes, and that e_{it} are iid across i, cointegration is said to hold if e_{it} are ‘jointly’ I(0), or in other words, $(1, -\beta)$ is the common cointegrating vector between y_{it} and x_{it} for all n units. They further state that failure to account for commons shocks can potentially invalidate estimation and inference of β.

Pedroni (2004) provides a series of test for the null hypothesis of no cointegration for pooled time series panels. Bai, Kao, and Ng (2007) provide consistent estimators of β_i in equation (5) in the presence of unobserved common stochastic shocks. In brief, Bai, Kao, and Ng (2007) adopt the framework that u_{it} in equation (5) has a common component and a stationary idiosyncratic component, thus $u_{it} = \gamma'_i F_t + v_{it}$ with F_t representing the unobserved common shock. This means that panel cointegration holds when $u_{it} = y_{it} - \beta x_{it} - \gamma'_i F_t$ is jointly stationary. Bai, Kao, and Ng (2007) treat the common shocks F_t as parameters and estimate them jointly with β using an iterated procedure. Two consistent estimators are derived from this procedure, the CupBC estimator which estimates and corrects for the asymptotic bias at the final stage of the iteration and CupFM which estimates and corrects for the asymptotic bias at every iteration. Readers are referred to Bai, Kao, and Ng (2007) for further discussion.

An additional point of clarification is that equation (5) contains both I(1) and I(0) regressors. The estimated coefficients for the I(0) regressors need no correction for the presence of the common shocks. On the other hand, the estimated coefficients for the I(1) regressors have distributions as if there are no I(0) regressors except the intercept. To obtain estimates for the parameter of the I(0) regressors we use the least squares dummy variables (LSDV) model (Kmenta, 1997, pp. 631-635). The residuals from the LSDV model with all regressors included are then used in the joint estimation of the common unobserved shocks and the coefficients of the I(1) regressors (see Bai, Kao, and Ng 2007, pp. 18-19 for further discussion).

5. EMPIRICAL RESULTS

Panel cointegration tests are reported in Table 1. We report Pedroni's (2004) panel *t-stat* and group *t-stat*, two of Pedroni's most powerful statistics. Both statistics reject the null of no cointegration. These results provide support for use of the panel cointegration models discussed above. Results using the Park's method are reported in Table 2, and the LSDV, CupFM and CupBC estimates are reported in Table 3. Overall there is little difference in the estimates of the I(0) regressors using the Park's method and LSDV method; however, the goodness of fit (R^2) is higher for the LSDV method.

Table 1. Pedroni's Tests of the Null Hypothesis of No Cointegration

Test	Fresh	Frozen
Panel *t-stat*	-7.558 (0.0001)	-3.459 (0.0003)
Group *t-stat*	-42.663 (0.0001)	-10.301 (0.0001)

Note: Numbers in parentheses are the probabilities values.

The following discussion is limited to the LSDV estimates and the CupFM and CupBC estimates in Table 3. The estimates in Table 2 are presented for comparison only. Although relatively small, the time effects are significant for both the fresh and frozen models. Past studies suggest that the time effects account for changes in the marginal product overtime. It is unlikely that the marginal product would change within a six-year time period and the negative time effects may reflect the trend in import prices more so than technological decline in fish importing. As expected, the output (re-export) price effects are positive for both fresh and frozen fillets. The estimate for α (0.355) in the fresh fillet model indicates that for every percentage increase in the re-export value, import prices increased by 0.36%. A percentage increase in frozen fillet re-export values results in a 0.19% increase in import prices. The country effects (λ) indicate discriminatory pricing in Kenya (fresh fillets) and Uganda (frozen fillets). This is likely due to the EU accounting for 98% of all fresh exports from Kenya and 60% of all frozen exports from Uganda. Although the EU accounted for 90% and 65% of fresh exports from Uganda and Tanzania, results indicate no evidence of price discrimination between the two countries. In the frozen fillet market, the EU accounted for 60% of Uganda's exports, but only 35% and 10% of exports from Tanzania and Kenya.

The exchange rate term (e) is defined such that a shilling devaluation (or euro appreciation) is indicated by an increase in e. In both import markets (fresh and frozen fillets)

EPT was incomplete for all exporting countries. As noted by Rakotoarisoa and Shapouri (2001), incomplete EPT is the results of noncompetitive pricing only when the country effect is also significant, but in the absence of a significant country effect, incomplete EPT may be the result of changes in the supply and demand elasticities.

Table 2. Parameter Estimates of the Fixed-Effects models (Park's method) for EU Import Prices of Fresh and Frozen Fillets from Lake Victoria

	Fresh			Frozen		
Parameter	Estimate			Estimate		
Intercept	7.489	(0.765)	[a]***	7.223	(0.894)	***
	Time effects					
θ_{01}	-0.111	(0.030)	***			
θ_{03}	-0.092	(0.030)	***	-0.076	(0.030)	**
θ_{04}	-0.076	(0.032)	**	-0.222	(0.036)	***
θ_{05}				-0.083	(0.033)	**
	Country effects					
λ_{Kenya}	2.003	(0.685)	***	-0.048	(0.605)	
λ_{Uganda}	-0.375	(0.531)		1.282	(0.726)	*
	Output price effect					
α	0.137	(0.061)	**	0.107	(0.092)	
	Exchange rate effects					
β_1 [b]	-0.959	(0.144)	***	-0.436	(0.140)	***
β_2	-0.244	(0.095)	***	-0.434	(0.110)	***
β_3	-0.326	(0.085)	***	-0.283	(0.086)	***
	R^2=0.37			R^2=0.45		

a Asymptotic standard errors are in parentheses.
b 1, 2, and 3 are Kenya, Uganda and Tanzania respectively.
*** Significance level = 0.01.
** Significance level = 0.05.
* Significance level = 0.10.

Exchange rate estimates suggest that EU importers were able to adjust fresh and frozen import prices downward when currency values declined in the exporting countries. The results show that a devaluation in the Kenyan shilling (1% increase in *e*) results in a 0.95% decrease in fresh fillet import prices denominated in euros. This indicates that 0.05% is passed through to prices denominated in Kenyan shillings. A devaluation in the Ugandan shilling results in a 0.30% decrease in fresh import prices (in euros) which indicates that 0.70% is passed through to fresh prices denominated in Ugandan shillings. If the Tanzanian shilling is devalued, fresh import prices (in euros) decrease by 0.35%, indicating that 0.65% is passed through to fresh prices denominated in Tanzanian shillings. The EPT incompleteness is relatively large for fresh fillets from Kenya. Given that the country effect (λ) for Kenya was also significantly different from zero, the relatively large incomplete EPT is likely due to the combined effects of changes in supply and demand, and discriminatory pricing. Pooled estimates of the exchange rate effect (β), which are statistically superior to the LSDV estimates indicate an average pass through of 0.50% (Pooled LSDV), 0.48% (CupFM) and 0.60% (CupBC).

Table 3. Parameter Estimates of the Fixed-Effects models (LSDV, CupFM and CupBC methods) for EU Import Prices of Fresh and Frozen Fillets from Lake Victoria

LSDV Estimates						
	Fresh			Frozen		
Parameter	Estimate			Estimate		
Intercept	6.187	(0.965) [a]	***	6.895	(0.845)	***
	Time effects					
θ_{01}	-0.167	(0.035)	***			
θ_{02}	-0.160	(0.025)	***	-0.074	(0.022)	***
θ_{03}	-0.126	(0.020)	***	-0.104	(0.017)	***
θ_{04}	-0.114	(0.022)	***	-0.285	(0.022)	***
θ_{05}				-0.096	(0.021)	***
	Country effects					
λ_{Kenya}	1.910	(0.673)	***	0.010	(0.453)	
λ_{Uganda}	0.122	(0.656)		1.516	(0.572)	***
	Output price effect					
α	0.355	(0.068)	***	0.189	(0.095)	**
	Exchange rate effects					
β_1 [b]	-0.950	(0.114)	***	-0.480	(0.104)	***
β_2	-0.300	(0.094)	***	-0.484	(0.084)	***
β_3	-0.351	(0.061)	***	-0.303	(0.061)	***
		R^2=0.67			R^2=0.85	
Pooled LSDV, CupFM and CupBC estimates for β						
	Exchange rate effects					
Pooled LSDV	-0.501	(0.353)	***	-0.798	(0.032)	***
Pooled CupFM	-0.518	(0.115)	***	-0.765	(0.112)	***
Pooled CupBC	-0.403	(0.065)	***	-0.719	(0.271)	***

a Asymptotic standard errors are in parentheses.

b 1, 2, and 3 are Kenya, Uganda and Tanzania respectively.

*** Significance level = 0.01.

** Significance level = 0.05.

* Significance level = 0.10.

For frozen fillets, the LSDV exchange rate effects for each country are relatively close, -0.48 for Kenya and Uganda, and -0.30 for Tanzania. Results show that the pooled exchange rate estimates were significantly greater than the individual country exchange rate estimates. Depending on the pooled estimate considered, a devaluation of the exporter's currency will decrease frozen imports prices (in euros) by 0.80% (LSDV), 0.76% (CupFM) or 0.72% (CupBC), indicating that only 20% to 28% of currency devaluations are passed through to frozen fillet prices denominated in shillings for either of the three exporting countries.

6. SUMMARY AND CONCLUSIONS

This study addressed the pricing-to-market behavior and completeness of exchange rate pass-through in the EU market for fish from Kenya, Tanzania and Uganda. Given the high concentration of Lake Victoria fish in the EU, EU importers were able to adjust fresh and frozen import prices downward when currency values declined in the exporting countries, and discriminatory pricing was found for Kenya (fresh imports) and Uganda (frozen imports).

Pooled estimates of the exchange rate effect for fresh fillets indicated that 50% of currency devaluations are passed through to import prices denominated in the exporter's currency. Pooled estimates indicated a greater degree of EPT incompleteness for frozen fillets where only 30% of currency devaluations are passed through to exporter-denominated import prices.

The results of this study imply that macroeconomic policy such as exchange rate adjustments can lose its effectiveness for generating export revenue in the face of imperfect markets. This finding is very important given that the SAP policies of the IMF and World Bank include currency devaluations as important to economic development strategies. This suggests is that the expected benefit of currency devaluations are not fully realized in the importing country and that EU importers simply adjust prices downward when shilling values decline. This is particularly true for Kenya (in the fresh fillet market) where not only was there evidence of price discrimination, but the incompleteness of EPT was relatively high (.95). We would expect that exchange rate policy would have little effect on fresh fillet exports in Kenya. In the frozen fillet market, EPT incompleteness was relatively high across all countries (combined effects: -0.72 to -0.80). Lastly, given that evidence of price discrimination was found for Uganda in this market, it is likely that the behavior of EU importers could negate the impact of exchanges rate policies in this country also.

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FOOD AID, SURPLUS DISPOSAL AND MULTILATERAL TRADE AGREEMENTS: WHAT IS THE HISTORICAL JUSTIFICATION FOR NEW WTO RULES?

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ABSTRACT

The latest round of WTO negotiations has generated proposals that would constrain food aid shipments under the export competition pillar of a new agriculture agreement. Competing exporters are concerned that new export competition disciplines will push commodities that would have otherwise been shipped under export subsidies or credit guarantees into food aid, thereby reducing the effectiveness of a new export competition pillar. This concern is premised on the assumption that food aid is an alternative outlet to export subsidies and credit guarantees for agricultural commodities. This article tests that assumption in a time-series model using historical data from the US and finds that changes in shipments of commodities under export subsidy and credit guarantees have not significantly affected food aid shipments. The model's results are discussed in the context of current WTO proposals on food aid, and suggest that negotiating parties may be overzealous in their attempts to collar food aid shipments.

JEL codes: Q17, Q18, F13, F53, O24
JEL keywords: food aid, WTO, export competition, agricultural trade, development economics

INTRODUCTION

The negotiations over export competition disciplines in the World Trade Organization's (WTO) Doha Development Agenda (DDA) have included spirited debates over the inclusion of food aid rules. The food aid guidelines that emerged from the Uruguay Round Agreement

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on Agriculture (URAA) have not been followed by some donor member countries[1] and DDA negotiators appear determined to include new rules that will be binding and enforced to the standard of other elements of a new Agreement. The presence of food aid rules in international trade negotiations is the result of an intersection of the interests of two, often divergent, groups; humanitarian advocates and competing agricultural exporters. Humanitarian advocates hoped that the coercive measures of the WTO's Dispute Settlement Understanding could be brought to bear on donors to modify their food aid policies (minimum donation requirements, untying aid, etc.) because the Food Aid Convention and the Food and Agricultural Organization's Consultative Subcommittee on Surplus Disposal have not been effective in governing international food aid shipments (Barrett and Maxwell, 2006).

Agricultural exporting member countries of the WTO viewed the prospect of new disciplines on export subsidies and credit guarantees as ill-fated without rules on food aid, which is widely perceived to have been used as a tool of surplus disposal for some food aid donors. This aspect of the DDA negotiations has been framed by the dispute over export competition between the EU and the US. US food aid policies are the primary targets of new DDA food aid proposal for two reasons. First, the US is the only large donor that still donates most of its aid in-kind; in-kind, as opposed to cash-based, food aid is most commonly associated with surplus disposal motives and can be highly distortionary in recipient countries. The second reason is the reciprocal nature of WTO negotiations; EU negotiators are seeking concessions on food aid from the US in return for reductions in EU export subsidies. New rules that emerge from a DDA deal will apply to all (developed) member countries, but are primarily targeted at the US.

The WTO agreements are fundamentally commercial trade agreements, not humanitarian or economic development treatises. As a result, the most recent draft documents to emerge from the DDA negotiations appear to tip towards the interests of competing agricultural exporters by outlining rules that limit the circumstances under which food aid shipments will be allowed instead of imposing positive food aid obligations (ex: minimum donation requirements) on member countries. The underlying concern of some competing exporters is that as new rules decrease the volume of commodities that is shipped under export subsidies and credit guarantees, some of these commodities will be channelled into food aid and potentially displace commercial trade in recipient-country markets (WTO 2008). The effectiveness of the proposed new rules on export competition, including food aid, is questionable (Cardwell 2008), but a premise on which new food aid rules is based is that food aid is an alternative outlet to export subsidies and credit guarantees.

Given the importance of new food aid rules in a DDA trade deal, it is worth testing the validity of this premise. This article examines the historical relationship between alternative forms of export competition and provides econometric estimates of the impact of changes in one outlet on changes in other outlets. A time-series model is developed that generates impulse response functions for shocks to hypothesised alternative forms of export competition.

[1] Article 10 of the URAA includes guidelines on food aid shipments in an effort to avoid circumvention of export subsidy commitments. These guidelines have not been followed by all member countries and are not enforced. See Cardwell (2008) for a discussion of these guidelines.

The model's results indicate that food aid has not served as a large or significant alternative vent to export subsidies or credit guarantees. A new WTO deal would generate a structural rule change in export competition disciplines that is outside the sample of the estimation; specifically binding limits on export credit guarantees and the possible elimination of export subsidies. As such, the model's results must be interpreted in an historical context. However, the results of this research suggest that negotiating parties may be overestimating the historical relationship between food aid and export competition in their attempts to collar food aid shipments.

Section 2 provides an overview of food aid rules in the WTO as well as an outline of proposed disciplines on export competition that have emerged from DDA negotiations. Section 3 introduces the conceptual and empirical models and describes the data. Section 4 explains the empirical results and discusses the model's findings, and section 5 concludes with observations.

FOOD AID AND THE WTO

The government provision of export subsidies and export credit guarantees have proven to be challenging obstacles at the DDA negotiations. Despite the difficulty in reaching agreement on the scale and scope of new export competition disciplines, new rules on export subsidies and credit guarantees are certain to appear in a final DDA agreement. Because of these new rules on export competition, a DDA agreement will also include binding rules on food aid shipments, which many negotiating parties view as having been used as an alternative to export subsidies and credit guarantees for disposal of domestic agricultural surpluses. An important concern among negotiating parties is that as the quantity of commodities that is shipped under export subsidies and export credit arrangements declines, there will be added pressure on donor countries to dispose of commodities as food aid. Such food aid (particularly if it is untargeted[2] in-kind aid) may displace commercial trade in recipient countries, thereby undermining the benefits of tighter constraints on export subsidies and export credits. This section provides a brief outline of proposed disciplines on export subsidies, credits and food aid.[3]

Food aid disciplines in the DDA have evolved over the past few years as negotiating parties have struggled to find middle ground that is acceptable to all member countries. Early proposals, such as the guidelines in the URAA (ex: untying food aid from donor sourcing) and earlier DDA draft modalities (ex: phasing out in-kind aid) no longer appear in WTO documents. Positive obligations for member countries, such as those appearing in the Food Aid Convention (minimum donation requirements, specification of acceptable commodities), are also absent from the proposals. Rather, food aid proposals are negative in nature, and outline the circumstances in which food aid shipments would not be subject to export competition disciplines.

[2] Untargeted food aid is sold on the open market in a recipient country. Targeted food aid is delivered to intended recipients.

[3] See Thompson (2007) for a more thorough examination of DDA proposals for export competition disciplines and Cardwell (2008) for a more thorough treatment of DDA proposals on food aid.

It appears as though a final agreement will contain a "safe box" for emergency food aid. Safe box aid will be exempt from export competition disciplines and allowed only in circumstances that meet the WTO's definition of allowable emergency food aid. There is great hesitancy on the part of WTO negotiators to venture into the assessment of a food emergency, and negotiators acknowledge that the WTO's expertise is in commercial trade, not in humanitarian and development assistance (WTO 2007a). As such, it appears as though the WTO would defer to humanitarian and development organizations for the declaration and assessment of food emergencies. The current proposal is that a declaration of an emergency by either the affected region's government or the United Nations would trigger safe box food aid.

Working papers that appeared early in the DDA negotiations (WTO 2006c) broached the possibilities of eliminating donor-sourced in-kind aid and phasing out monetized aid.[4] Competing exporters argue that monetized food aid is not additional consumption and necessarily displaces either commercial imports or domestic production, or both. Development advocates argue that monetized food aid can depress local food prices and generate disincentives for local producers because it is untargeted. Elimination of donor-country sourced in-kind and monetized aid has met with resistance, however, and these proposals have been watered down in subsequent negotiations. The proposals from the February 2008 modalities are less instructive, and simply encourage members to make "their best efforts to move increasingly towards more cash-based [instead of in-kind] food aid." (WTO, 2008). There is no requirement for the elimination of in-kind food aid. Agricultural exporters (chiefly the US[5]) appear determined to hang on to donor-country sourced in-kind commodity donations as an option. US negotiators have indicated that if food aid programs are disciplined in a manner that would reduce the volume of in-kind aid shipments, they do not anticipate that US cash-based aid will increase sufficiently to fill the void (Abbott, 2008).

The elimination of monetized aid has also raised the ire of some non-governmental aid agencies, many of whom rely on the proceeds from monetized aid to fund development and humanitarian projects.[6] The February 2008 (WTO, 2008) draft modalities call for monetized aid in the safe box to be limited to situations that generate funds to finance the delivery of food within the recipient country. Monetization of non-emergency food aid is to be allowed only for the financing of food delivery or the procurement of agricultural inputs (though most of this section falls within square brackets, indicating the lack of consensus on this issue).

Proposed DDA food aid disciplines have been well received by many developing countries who are frequent recipients of food aid. Submissions by African and least-developed countries (WTO, 2006a) and by the G-20 group of developing countries (WTO, 2006b) indicate that these member countries are satisfied that new disciplines will not impede legitimately needed food aid.

The presence of food aid disciplines in the export competition pillar of the DDA speaks to the concern that member countries have about food aid being used as a method to dispose of agricultural commodity stocks, and the potential for food aid displacing commercial trade

[4] Monetized aid is in-kind aid that is delivered to the recipient country and sold on the local market. Proceeds are often used for development-related projects.

[5] The US negotiating position has been in favour of continuing current food aid disciplines as outlined in Article 10.4 of the URAA (Young 2002).

[6] There are also several food aid organizations who oppose the monetization of food aid. Oxfam and CARE, two large international food aid donors, have both expressed opposition to monetization.

in recipient countries. In fact, the tightening of export subsidy and export credit disciplines was a primary motivation for member countries to negotiate the inclusion of enforceable food aid disciplines in the DDA round. This motivation can be viewed as having two bases. The first is that EU negotiators sought reciprocal concessions from the US in response to requested reductions in export subsidies. The second is that tighter constraints on export subsidies and credit guarantees could push commodities into food aid and displace commercial imports. This article analyses the latter. The notion that food aid can lead to commercial displacement is widely accepted among WTO member countries, and the July 2007 draft modalities (WTO, 2007b) contain specific reference to rules that will ensure the elimination of commercial displacement that is caused by food aid. It is therefore worth discussing the directions that export subsidy and credit disciplines might take in a DDA deal.

The DDA negotiations have included ambitious proposals on disciplining agricultural export subsidies and export credits. The agenda for export subsidies is clear; member countries intend to eliminate agricultural export subsidies over an implementation period by 2013. If this discipline is enforced, then the quantity of commodities that are shipped under export subsidies will fall to zero.

The debate over export credits is less clear. The intention of many negotiating parties is to eliminate the subsidy element from officially supported export credits; the means by which to achieve this goal is as yet uncertain. The July 2007 modalities outline several key objectives including: 1) requiring repayment terms of fewer than 180 days, 2) requiring payment of a minimum interest rate, 3) requiring premiums to cover the risk of non repayment, and 4) requiring a credit program to be self financing. An export credit program that is outside of these disciplines would be considered an export subsidy and have to be eliminated by 2013.[7]

DDA negotiations have also included proposals for disciplining exporting state-trading enterprises (STEs) (WTO, 2008). The primary thrust of DDA proposals for STEs is the elimination of the subsidy element to their operations, including food aid and export credits. STEs in developing member countries shall receive special and differential treatment, including allowance for programs that stabilize domestic prices and food supply. Young (2005) provides a detailed treatment of STEs in DDA negotiations.

The fallout from a DDA deal will be fewer commodities shipped under export subsidy and credit arrangements. Whether this pushes more commodities into food aid will be an empirical question that will have to be evaluated after a DDA implantation period. However, an assessment of whether this relationship has existed in the past can be conducted using historical data. The forthcoming model investigates that historical relationship.

MODEL AND DATA

The inclusion of food aid disciplines in the export competition pillar of the DDA negotiations is premised on three assumptions. First, that new disciplines on export subsidies and credits will be binding and effective. The effectiveness of new rules on export competition is far from certain (Thompson 2007), and will have to be evaluated after an

[7] There are several important obstacles to a resolution of the negotiations over export credits. These include determining the subsidy element and special and differential treatment for developing countries. See Thompson (2007) for a discussion of these issues.

implementation period has passed. A second assumption is that food aid may displace commercial trade in recipient-country markets. The degree of displacement depends heavily on the level of targeting and the type of aid delivered (i.e. emergency vs. program), but there is empirical evidence of such effects (Barrett et al. 1999; Lowder 2004). The February 2008 Draft Modalities (WTO, 2008) expressly cite preventing commercial displacement as a goal of new food aid disciplines. The third assumption is that tighter constraints on export subsidies and credit guarantees could push WTO member countries to channel commodities that were previously sold under export subsidies or credit guarantees into food aid.

This third assumption will ultimately have to be evaluated after an implementation period. However, the historical relationship between forms of export competition and food aid can be investigated to determine if there is historical justification for the belief that food aid has been used as an alternative to export subsidies and credit guarantees. If negative covariate, contemporaneous and lagged, relationships between food aid and export competition can be established empirically then WTO member countries may be justified in their concern about food aid having been used as a tool of surplus disposal. If such relationships cannot be observed, then there may be overzealousness on the part of negotiating parties to confine food aid shipments. The results of an empirical analysis can inform trade policy negotiations.

Modelling this relationship empirically requires an assessment of how changes in one proposed form of export competition affects others; specifically, how changes in the volume of commodities shipped under export subsidy or export credit arrangements have affected food aid shipments. The URAA implementation phase of 1995-2000 provides a unique sample in which allowable export subsidies were decreased according to The Agreement's disciplines. It seems reasonable to investigate a causal relationship between reductions in allowable export subsidies and changes in food aid shipments over that period. The nature of the URAA scheduled reductions make the investigation of such a relationship impossible, however. Export subsidies were bound at levels high enough so that not all member countries were utilising all of their allowable allotments. This is particularly the case in the US where export subsidies for wheat fell out of favour with the demise of the Export Enhancement Program in 1997. Export subsidy disciplines were not binding and reductions in allowable subsidies did not translate into reductions in actual subsidies. This "water" in allowable export subsidies prevents the empirical establishment of a causal relationship between alternative forms of export competition. The URAA did not contain explicit export credit disciplines[8], so a link cannot be established between mandated decreases in export credit guarantees and food aid shipments.

An alternative approach is to investigate the historical time-series relationships between alternative forms of export competition. This can be done by treating hypothesized alternatives as endogenous to each other and estimating the interactive effects of each by means of a vector autoregression (VAR). The model's estimated parameters and constructed impulse responses provide insight into the degree to which changes in the volume of commodities shipped under one tool affect changes in the others.

[8] The WTO decision on cotton illustrates that some export credit arrangements can be interpreted as export subsidies. Export credit guarantees provided for cotton exports from the US were deemed to be export subsidies by both an initial and appellate WTO panel (Young, 2005).

The US is chosen as the subject of the theoretical and empirical investigations. The US is investigated for several reasons. First, the US is by far the largest donor of food aid, accounting for approximately 56% of global food aid shipments by volume over the past ten years (WFP Interfais). Second, the US is the primary donor of in-kind aid and the donor country most frequently accused of using food aid as a tool of surplus disposal (Young 2002; Barrett and Maxwell 2005); if an empirical relationship exists between forms of export competition then it is likely to be found in these data. Finally, the data required for time-series analysis are most readily available from for the US.

Other major food aid donors are less likely than the US to exhibit significant relationships between alternative forms of export competition and food aid deliveries, especially in recent years. The EU's food aid policy was reformed in 1996 to better address global development issues by emphasizing factors such as local and triangular purchases (European Commission, 2000) and Canada announced in April of 2008 that future food aid procurement is to be completely untied, after partially untying procurement in 2005.

New agricultural disciplines from a DDA deal would apply to all (developed) member countries, however food aid rules are primarily aimed towards the US. Negotiators from the EU are pushing for food aid constraints in response to US pressure for reductions in EU export subsidies. This reciprocal trade-off between EU and US negotiators has framed much of the food aid debate in the DDA. However the nature of WTO negotiations is that all rules must apply to all members (special and differential treatment for developing-country members aside); disciplines on EU export subsidies must apply to all member countries, and likewise for disciplines on US food aid shipments. Young (2005) points out that new disciplines must be specific enough to address the current concerns of negotiating parties, while remaining broad enough to discipline future, unforeseen policy developments. Given that US food aid programs have historically (Schultz 1960) been motivated by the need to dispose of surplus commodities that were acquired through the United States Department of Agriculture's (USDA) loan rate program, there is concern on the part of negotiators that new export subsidy and credit guarantee rules could result in the circumvention of export competition rules by encouraging member countries (specifically the US) to ship more commodities as food aid.

The evolving nature of USDA programs has sharply reduced the public acquisition of grain stocks in the US, however. The deficiency payment program sharply reduced the Commodity Credit Corporation's (CCC) acquisition of stocks; stocks that were once an important source for US food aid shipments. The USDA estimates that an average of just under 30% of food aid shipments between 1992 and 2004 were procured from USDA inventories. The remainder were procured through open market operations from private dealers (USDA, 2006b). Though the role of food aid in disposing of CCC stocks has declined[9], the US continues to use in-kind food aid donations for non-humanitarian policy objectives. Barrett and Maxwell (2005) describe the "iron triangle" of interest groups who benefit from continued in-kind donations; these groups include food processors, maritime interests and non-governmental organisations that rely on the proceeds from monetised food aid.

[9] The USDA reports (USDA, undated) that Section 416(b) food aid is currently inactive because of a lack of CCC commodity stocks

It is interesting to note that benefactor-countries of export credit guarantees are often different than traditional recipients of food aid.[10] The OECD (2000) reports that the majority of export credit programs are provided to OECD countries, and are generally not used to address liquidity constraints in developing countries. For example, the US - by far the largest user of export credit guarantees - provides approximately 60% of its export credit guarantees to other OECD countries (OECD, 2000). OECD countries are not significant recipients of international food aid. Less than 10% of all export credits have been granted to net-food importing developing countries (OECD, 2000). Despite these observations export credit guarantees and food aid could have been used as policy substitutes in the past; commodities may have been transferred between uses, though likely to different recipient countries. However these observations generate some *a priori* scepticism to the establishment of a significant empirical relationship between export credit guarantees and food aid shipments. Furthermore, the institutions that have been used to finance and administer export credit programs differ from food aid administration programs. Nearly 98% of export subsidies in the US have been applied to dairy exports through the Dairy Export Incentive Program (Young, 2001). Dairy is a minor food aid commodity, and the ability for policy makers to easily transfer resources from an export credit program to a food aid program could be limited by institutional factors.

Using the institutional structure of the US for the basis of the model, commodities sold under export subsidy or credit arrangements, food aid shipments and carry-over stocks are treated as theoretical alternatives. Figure 1 illustrates how the VAR captures the relationship between proposed outlets.

Domestic production is divided into two portions - commercial trade and domestic surplus. The surplus that is analyzed in the VAR is divided into three outlets; commodities can be shipped under export subsidies or credit arrangements (traditional export competition tools), shipped as food aid, or held as carry-over stocks into the next period. The model hypothesizes that these three alternative outlets share an endogenous relationship, and that changes in one affect changes in others. A VAR that is estimated using historical data can reveal the significance of such a relationship. The model also controls for circumstances in which food aid shipments have been particularly large in response to foreign assistance programs. US Official Development Assistance (ODA) spending is included as an exogenous control variable to account for periods in which food aid flows may have been affected by factors other than the endogenous relationships outlined in figure 1. A large food aid response to a humanitarian crisis or foreign policy objective are examples of such a situation, where ODA spending on the crisis would be large and an associated increase in food aid is not related to domestic stocks or export subsidies and credits.

It is worth making a few important points about using VAR analysis for the current research. First, there is no attempt to estimate or explain the size of the domestic surplus or the relationship between the size of the surplus and the outlets. Export competition policies could impact the size of a country's surplus, however modelling this relationship is outside the scope of this research. This limitation is acknowledged. The objective is to test for and estimate dynamic endogenous relationships between a group of proposed outlets given a fixed surplus. Once these relationships are determined, one can infer how changes in the use of one vent have affected the use of others. Second, a new WTO agreement would presumably

[10] Thanks to an anonymous referee for this observation

establish new trade rules, thereby introducing the Lucas critique (Lucas 1976) to the analysis. The importance of the Lucas critique in VAR analysis is a subject of debate (Stock and Watson 2001; Rudebusch 2002), but no attempt is made to forecast how commodity shipments under subsidy and credit arrangements would change after a DDA agreement. The goal is to understand if export subsidies, credits and food aid have been used as alternatives in the past, and to provide empirical estimates of these effects. Such knowledge is valuable in evaluating the motivations for including food aid disciplines in the export competition pillar of the DDA negotiations. Also, a new policy environment that develops as a result of a new WTO agreement does not render the historical relationship between variables meaningless. Donors have long felt the need to dispose of surplus commodities[11], and if food aid was an alternative to export subsidies or credit arrangements, then that relationship should be present in the data. If such a relationship cannot be established, or is not significant, then new WTO rules would not necessarily create such a relationship. This is especially true given evolving policies and institutions in important donor countries (most importantly, vastly smaller public stocks in the US).

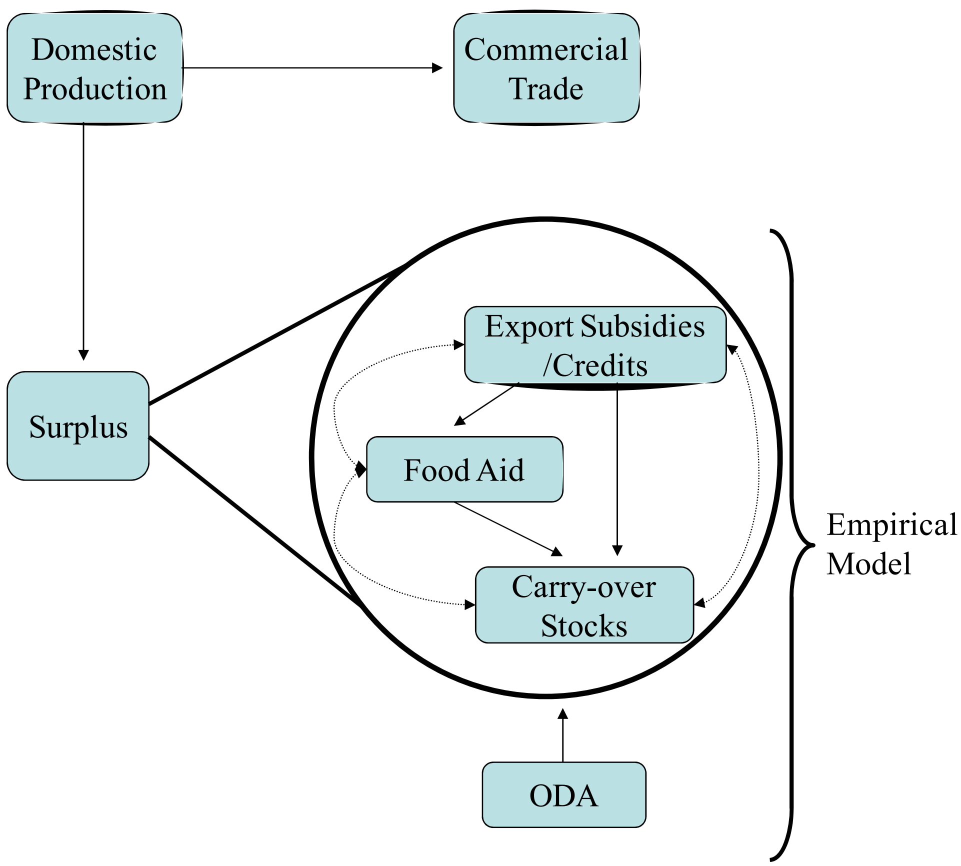

Figure 1. Conceptual Model

[11] US Congressman Harold Cooley's comments before the House Committee on Agriculture exemplify this historical concern: "We are primarily interested in getting rid of these surpluses and we don't care how you do it..." (US House of Representatives, 1959).

The structural-form VAR for a specific commodity is

(1) $$\mathrm{B}x_t = \Gamma_0 + \sum_{i=1}^{n} \Gamma_i x_{t-i} + \Pi z_t + \varepsilon_t \,.$$

x_t is a three by one vector of endogenous variables that includes the volume of exports shipped under subsidy or credit arrangements, food aid shipments and year-end carry-over stocks. x_{t-i} is a matrix of lagged endogenous variables and z_t is contemporaneous development assistance spending. B, Γ_0, Γ_i and Π are parameter matrices to be estimated. This structural-form model represents the relationships between the endogenous variables and between the exogenous variable and the endogenous system.

The structural form of equation (1) cannot be estimated in its current form because endogenous variables appear on both sides of the equation. The structural form can be reduced to standard form by inverting the B parameter matrix and reorganising terms to generate

(2) $$x_t = A + \sum_{i=1}^{n} C_i x_{t-i} + D z_t + e_t$$

where $A = B^{-1}\Gamma_0$, $C_i = B^{-1}\Gamma_i$, $D = B^{-1}\Pi$ and $e_t = B^{-1}\varepsilon_t$. Equation (2) is estimated as a VAR using ordinary least squares.

The standard form of equation (2) is under identified; the contemporaneous effects of parameter matrix B cannot be recovered without parameter restrictions. Theory provides a structural decomposition on the system to ensure identification, however. Within the system of endogenous variables, there is a hierarchy by which each outlet is utilized. Commodities are first sold under export subsidy or credit arrangements. This is the first portion of surplus that is disposed, and has direct contemporaneous effects (the solid lines in figure 1) on food aid shipments and carry-over stocks. The remainder is either shipped as food aid or held as carry-over stocks, with food aid being determined first. Carry-over stocks do not have contemporaneous effects on the other vents. This structural decomposition is operationalised by imposing the following constraints when recovering the structural-form parameters from standard-form parameter estimates:

(3) $$B = \begin{bmatrix} 1 & 0 & 0 \\ \beta_{21} & 1 & 0 \\ \beta_{31} & \beta_{32} & 1 \end{bmatrix}.$$

Food aid deliveries are persistent (Barrett et al. 1999; Diven 2001), so that aid in one period begets aid in the subsequent period. The parameter matrix Γ_i is left unrestricted to account for potential lagged effects in the endogenous system. These are the dotted lines within the circle of endogenous variables in figure 1.

The variables that make up the commodity surplus do not comprise a singular system. The use of the VAR methodology allows an examination of the relationships between endogenous variables without having to explain the disposition of all variables. This means that if a decrease of 100mt in commodities shipped under export subsidy arrangements is imposed on the VAR, then the other proposed outlets (food aid and carry-over stocks) need not increase by 100mt in the same period. The VAR conveys historical estimates of how the group of endogenous variables has moved together over the sample period.

The interpretation of effects from the estimated parameters in equation (2) is as follows: a change in the volume of wheat sold under export subsidies or credit guarantees from period $(t-2)$ to period $(t-1)$ of k metric tonnes changes food aid shipments from period $(t-1)$ to period t by k metric tonnes times the estimated parameter on the export competition variable, *ceteris paribus*. These effects are updated to simultaneous effects using the restrictions from equation (3).

The data are taken from several sources and are comprised of US wheat[12] shipments. Food aid data are compiled from three USDA sources (Hoffman et al. 1995; Suarez 1994; USDA, 2006a) and comprise US wheat shipments from 1954 to 2004. Shipments from major US food aid programs[13] (PL480, Section 416 and Food for Progress) are aggregated into one variable. Some US food aid programs are likely to be more closely related to surplus disposal motives than others, especially Section 416 shipments. However the evolving nature of US food aid programs precludes modelling the relationship between surplus disposal outlets and each aid program individually. The structures of PL480 food aid programs were redesigned in 1975 to change the allocation policies between PL480's various "titles", and wheat volumes delivered under Section 416 have waxed and waned over the past 20 years. Because of these changing policies, a decision was made to aggregate all food aid programs into one variable that would capture policymakers' broad use of food aid as an export competition tool. Aggregating food aid data into one variable also provides a larger sample, which is important in the estimation of time-series models.

Export credit data comprise CCC export credit programs, which are taken from Hoffman, et al. (1995) and from the annual USDA Wheat Yearbook. Export subsidy data are taken from the Wheat Yearbook and include Export Enhancement Program shipments from 1986 to 1996. Wheat shipped under export subsidies and credits are aggregated into one variable for the empirical application. While it is possible that not all of the shipments sold under credit arrangements contained a subsidy element, the series are aggregated to discern the effects of an overall decline in subsidy and credit shipments (the goal of export competition disciplines in a potential DDA deal) on food aid shipments. Also, aggregating these data provides an adequate time series for VAR estimation.

Year-end stock data comprise both public and private stocks. Some US food aid programs, especially Section 416, draw exclusively from public stocks, however Section 416 shipments have fallen sharply over the past several years and are currently zero (USDA, undated). A large share of US food aid shipments are now taken from private stocks in

[12] Wheat has accounted for approximately 50% of aid shipments by volume over the past ten years (WFP Interfais) and is the most important food aid commodity.

[13] Food aid that is sold concessionally is not categorized as credit or subsidy shipments because the US currently reports such shipments as food aid, not as credit or subsidy shipments. It is possible that a new WTO agreement would require that all concessional sales be reported as such, and not as food aid.

response to invitations for bids that are issued to private firms. Private stocks, though volatile, now dwarf public stocks (figure 2). Stocks data are from USDA's Wheat Situation and Outlook Yearbook, 2006. The data are converted from crop year to fiscal year to allow stocks to act as a repository for wheat that is not sold under export subsidies/credits or shipped as food aid (all of which are reported in fiscal year terms).

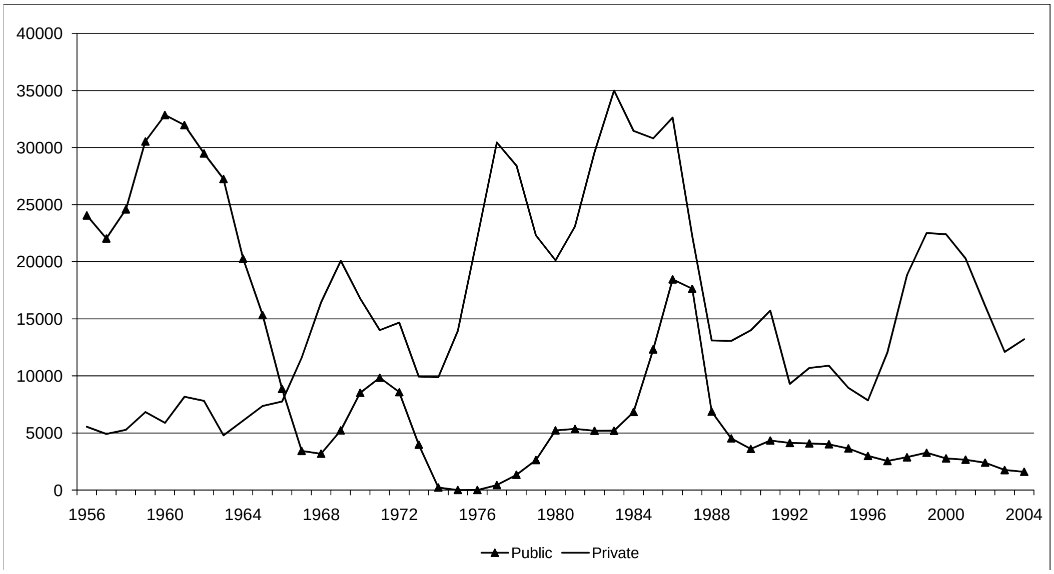

Figure 2. US wheat stocks (thousands mt)

The exogenous control variable is ODA spending. This accounts for periods of unusual food aid shipments that are not the result of an endogenous relationship between the postulated export competition alternatives. ODA data are from the OECD. All data are annual and the sample is 1956 to 2004. Figure 3 displays a plot of the endogenous series.

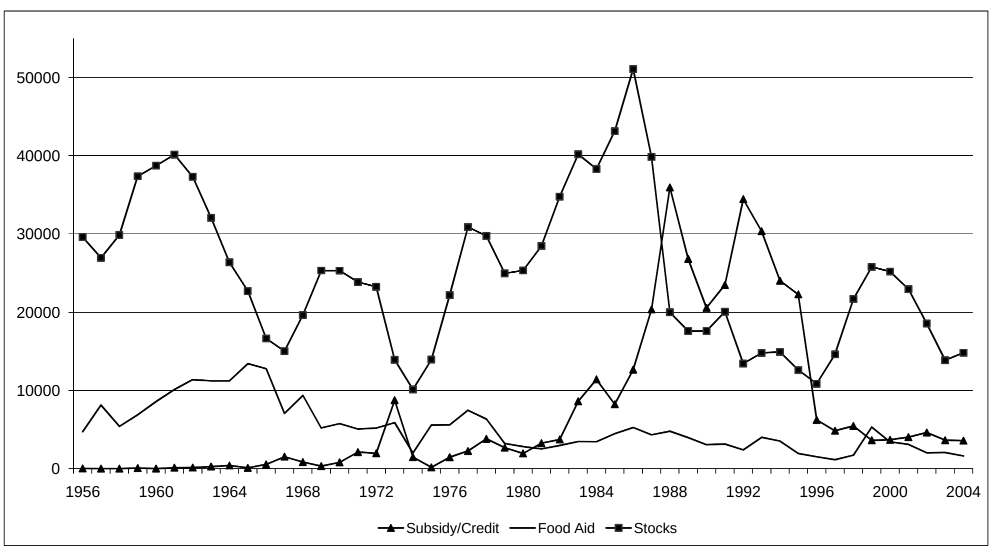

Figure 3. Raw Data (thousands mt)

ESTIMATION AND RESULTS

The data are first tested for unit roots. This is done using the stepwise augmented Dickey-Fuller procedure outlined in Enders (2004) to ensure inclusion of the appropriate deterministic variables in the test equations. The null hypotheses of unit roots in levels cannot be rejected for any of the series, including the ODA control variable. The same test rejects unit roots for all variables in first differences, indicating that the data is difference stationary.

The existence of a long-run equilibrium relationship between the hypothesized endogenous variables (food aid, export subsidies and credits, and carry-over stocks) is investigated by testing for cointegration. The stepwise Johansen procedure from Enders (2004) is used to ensure that the appropriate forms of the test equations are used. The optimal lag length for the test VAR is one, as determined by Schwarz Information Criteria. The presence of an intercept in the cointegrating test equation is tested using a chi-square statistic, and the null hypothesis of an intercept cannot be rejected. This relationship is tested for cointegration using the trace and maximum eigenvalue tests, and no cointegrating vectors are found using either test. Time-series tests conclude that the data are difference stationary, but are not cointegrated.[14]

The lack of cointegrating relationships between the variables means that a VAR must be estimated in first differences to account for the data's nonstationarity. The downside of estimating in first differences is that long-run relationships between the model's variables are not observed. While unfortunate, the loss of this information is not critical to this analysis as it might be in a study of food aid from a recipient country's perspective. We are primarily interested in the short-run impact of a change in one hypothesized alternative on the change in other hypothesized outlets from the donor's perspective. This is not to suggest that food aid cannot have long-run effects in recipient countries. For example, US PL480 Title I food aid is primarily intended for the promotion of US agricultural exports and advancing foreign policy objectives (Barrett and Maxwell, 2005), and PL480 Title III food aid was intended to provide funding for long-term development projects through monetization. These tools could certainly have long-run effects in recipient markets. The lack of cointegration between the endogenous variable limits the empirical results in this area.

The current WTO proposals on food aid are targeted at preventing commercial displacement, however. One would hope that WTO member countries view this as a short-run concern (in that competing exporters are concerned that a food aid shipment may displace a specific commercial transaction in a current year) and not a long-term concern (in that WTO member countries want to prevent food aid that would foster underlying economic development in the recipient country - something that might actually *increase* future demand for imported food). The long-run effects of food aid are fundamentally important from a development economics perspective, however negotiators involved in WTO consultations are focused primarily on the short-term effects on competing exporters from a trade policy perspective.

Standard-form parameter estimates for the VAR are reported in table 1. These parameters, in combination with the parameter restrictions of equation (3) and the estimated residual covariances, are used to recover the structural-form parameters of matrices B, Γ_0, Γ_i

[14] Econometric test results are available from the author by request.

and Π (table 2) by solving a set of simultaneous equations in MatLab. Our primary interests are the dynamic effects of changes in one hypothesized outlet on changes in other outlets. This information is obtained by generating impulse responses from the structural-form parameters in table 2. Impulse responses are based on the imposition of exogenous innovations on the endogenous variables and the tracing of effects on other variables in the system.

Table 1. Standard-Form Coefficients

	Dependent Variables		
Regressors	Credit/Subsidy	Food Aid	Carry-Over Stocks
Constant	251.5460	-139.7117	-97.7576
	(-718.20)	(-259.74)	(-784.27)
Lagged Subsidy/Credit	0.1759	0.0320	-0.2285
	(-0.16)	(-0.06)	(-0.17)
Lagged Food Aid	-0.0351	-0.3608	-0.2234
	(-0.39)	(-0.14)	(-0.42)
Lagged Carry-Over Stocks	0.2885	0.0966	0.3521
	(-0.14)	(-0.05)	(-0.15)
Overseas Development Assistance	-0.2513	0.0294	-0.1002
	(-0.51)	(-0.19)	(-0.56122)

Standard errors in parentheses
All variables in first differences

The February 2008 Draft Modalities (WTO, 2008) are used as guidelines for the innovations. One proposal calls for quantity reductions in export subsidies by twenty percent upon implementation of an agreement. Imposed innovations are therefore set to twenty percent of each shocked series' ten-year average. Impulse responses are presented in figure 4 with corresponding ± two standard error confidence bands.

Table 2. Contemporaneous Coefficients

	Dependent Variables		
Regressors	Subsidy/Credit	Food Aid	Carry-Over Stocks
Subsidy/Credit	1	-0.0113	0.5237
Food Aid	0	1	0.5255
Carry-Over Stocks	0	0	1
Overseas Development Assistance	0.1759	0.0300	-0.1195

All variables in first differences

We are primarily interested in the effects of a shock to subsidy and credit sales (figures 4a, 4d and 4g), which is approximately -1.2 million mt; note that a negative shock is imposed to be intuitively consistent with a WTO deal that reduces the volume of commodities shipped under subsidy or credit arrangements.[15]

[15] Innovations on all other variables are also negative for consistency. Food aid and stock shocks are equal to twenty percent of each series' ten-year average.

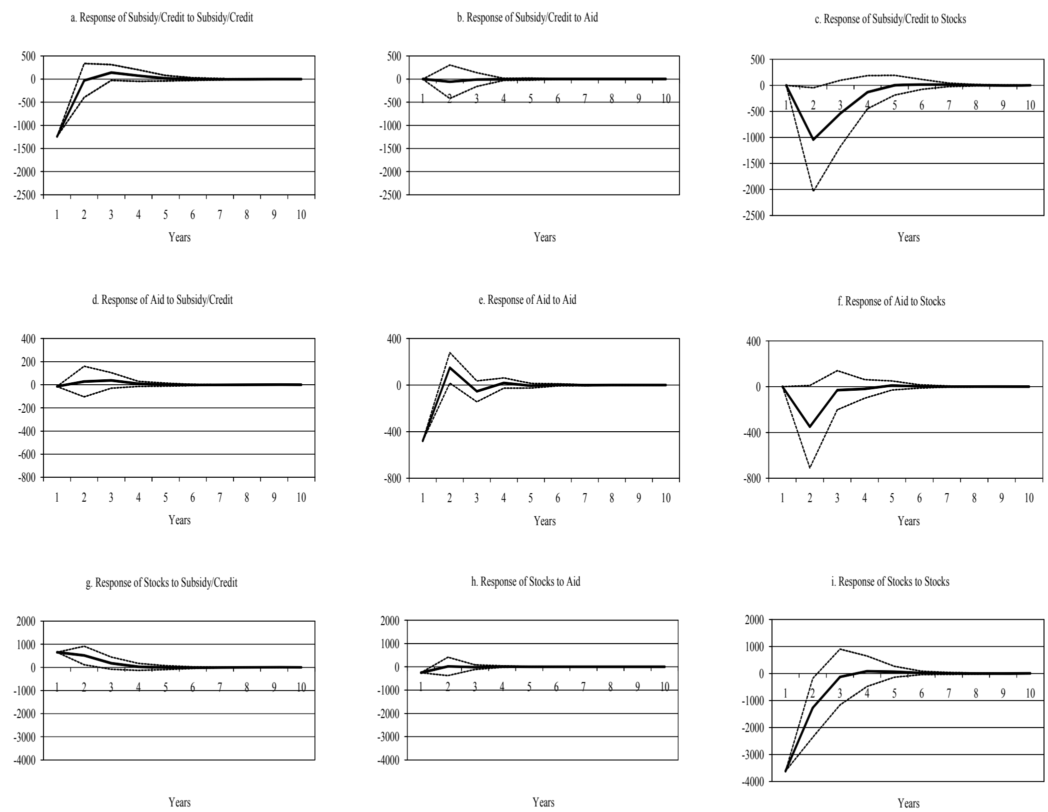

Figure 4. Impulse responses (with ± two standard errors)
Note: All responses in thousands of mt. Innovations are equal to -20% of the shocked variable's 10-year average

The immediate effect of the shock to subsidy/credit sales on food aid shipments (figure 4d) is a very small *decrease*. However, the confidence interval around the impulse response in figure 4d includes zero, implying that the response of food aid to a decline in subsidy and credit sales is not significant. The lagged effect on food aid is also very small, though consistent with the expectation that a decline in subsidy and credit shipments will increase food aid shipments - aid shipments increase by approximately 29,000 mt one period after the one-time shock. It is not surprising that a positive effect on food aid is not observed until one period after the initial shock. Institutional constraints delay the procurement and delivery of food aid, from five months for emergency aid to as long as two years for non-emergency aid (Barrett and Maxwell 2005). The effects on food aid shipments remain small thereafter, and decay towards zero by the end of ten periods. The confidence band encompasses zero throughout the horizon, implying little statistical significance of food aid's response.

Food aid responses are small relative to historical food aid shipments. The accumulated response of food aid to a twenty percent export subsidy/credit shock is approximately 61,000 mt after ten years. This amounts to less than one percent of total food aid shipments over the same ten-year period.

The effect on carry-over stocks is much more pronounced; a one-time decrease in commodities that are shipped under subsidy and credit arrangements generates a contemporaneous increase in carry-over stocks of approximately 656,000 mt (figure 4g). The constructed confidence band around the carry-over stock response indicates a statistically significant reaction to subsidy/credit shipments. The lagged effects decay thereafter, but remain larger than the effects on food aid. The accumulated response of carry-over stocks to the subsidy/credit shock is small relative to historical stock levels; a ten-year total response of approximately 1.4 million mt compared to a ten-year total of approximately 180 million mt. There appears to be very little inertia in subsidy and credit shipments (figure 4a), as the dynamic path decays quickly after following an inverse J-curve pattern.

The VAR's variance decompositions are displayed in table 3. This table conveys the percentage of the forecast error of selected responding variables that is attributable to changes in the system's other variables. These results are derived from estimated parameters and provide a complementary evaluation tool to the impulse responses in figure 4. The variance decompositions indicate that a change in subsidy and credit sales has little explanatory power in the dynamic behaviour of food aid shipments. The share of variation in the food aid response that is due to the subsidy/credit shock is less than one percent after one period and remains near one percent after ten periods. The contribution of carry-over stocks to the dynamic response of food aid is also small, reaching just five percent after five periods. The variation in carry-over stocks that is due to the initial shock to subsidy and credit shipments is much larger, reaching thirty-two percent after five periods.

Table 3. Variance Decompositions (%)

Aid			Carry-Over Stocks		
Lead (years)	Credit/Subsidy	Carry-Over Stocks	Lead (years)	Credit/Subsidy	Aid
1	0.10	0	1	23.52	3.03
5	1.09	5.33	5	31.79	2.43
10	1.09	5.33	10	31.79	2.43

The empirical model was estimated over alternative sample periods during the modelling process. For example, one trial period was 1954 to 1989 to correspond with the introduction of the US Food, Agriculture, Conservation and Trade (FACT) Act of 1990. The FACT Act increased the emphasis on humanitarian objectives in US food aid policy (Shapouri, Rosen and Meade, 2004); it is conceivable that the degree of substitutability between food aid and other forms of export competition could have been more significant prior to 1990. Estimation results do not corroborate this conception. The dynamic paths of responding variable are similar in nature to the paths estimated over the entire sample (though scales vary slightly). Given that the estimation results did not markedly change for different sample periods, a decision was made to include all observations to maximize the degrees of freedom in this time-series model.

The empirical model provides interesting insight into the historical relationships between export subsidy and credit sales, food aid shipments and carry-over stocks. A reduction in sales of wheat under export subsidy and credit arrangements has not had significant effects on food aid shipments. The model predicts that food aid shipments increase by a very small amount (less than five percent of the decrease in subsidy/credit sales) after several years, however confidence intervals indicate the responses are not statistically significant. The empirical model does not identify food aid as an important alternative outlet to subsidy and credit sales for the disposal of surplus wheat. The relationship between the two may deteriorate even further in the future (new WTO rules notwithstanding) because food aid deliveries are becoming more responsive to recipient-country need over time (Young and Abbott, 2008).

The use of export promotion programs has varied over the years in response to factors other than the motivation to dispose of surplus commodities; this variation may contribute to the lack of a significant relationship between subsidy/credit sales and food aid shipments. For example, export credit guarantees were more prevalent when importing countries were dealing with STEs, whose numbers have declined in recent years.[16]

There remains the possibility of an indirect dynamic link between subsidy/credit sales and food aid through carry-over stocks. The empirical model identifies a significant relationship between a change in subsidy/credit sales and carry-over stocks (figure 4g); these carry-over stocks can become food aid in the subsequent period. However this indirect relationship is small and not significant. Figure 4f illustrates the dynamic path of food aid in response to an innovation in carry-over stocks. Food aid responds in an amount that is less than ten percent of a shock to carry-over stocks, and the estimates are not statistically significant.

The empirical model is only applied to US wheat. However wheat is the most important food aid commodity from the largest donor, and the donor most often accused of using food aid as a tool of surplus disposal (Young 2002; Barrett and Maxwell 2005). If a relationship between export competition and food aid exists, then it should be detected here.

The lack of significant relationships may indicate overzealousness on the part of competing exporters in negotiating new food aid disciplines in the DDA. The hypothesized relationship between export subsidy/credit shipments and food aid is not identifiable in this econometric investigation. A new WTO deal will presumably establish new policy rules that will change the institutional structure in which the model was estimated. However the need to dispose of surplus agricultural commodities is not a new pressure for exporting countries; in fact it is of declining importance as domestic stocks contract. Even though food aid shipments may have grown in response to large domestic stocks, the model's results indicate that they have not expanded in response to decreased export subsidy and credit shipments. There may be exceptions[17] in which policy makers use food aid as an alternative, but it is far from clear that the great efforts that have gone into food aid negotiations and the ill-will that WTO negotiators have fostered among humanitarian NGOs have been based on historical experience. This is especially true if new disciplines on export competition prove difficult to implement and enforce (Thompson 2007; Cardwell 2008).

CONCLUSIONS

Negotiating parties in the DDA appear determined to constrain the use of food aid as an alternative to export subsidies and credit guarantees in hopes of averting commercial displacement. One of the key premises on which the incentives for new rules rests is that food aid is, or has been, an alternative outlet to export subsidy or credit arrangements. This proposition is tested empirically using historical data from the US. The model's results suggest that a change in export subsidy and credit sales of wheat has not significantly affected

[16] Thanks to an anonymous reviewer for this observation.

[17] Margulis (2007) has noted anecdotally that aid shipments of skim milk powder increased as donors encountered binding URAA export subsidy constraints.

the dynamic path of food aid shipments. Impulse responses of food aid are small and insignificant following a shock to the quantity of commodities shipped under export subsidy and credit guarantees. Variance decompositions confirm that changes in export subsidy and credit shipments are not driving forces behind changes in food aid shipments.

The empirical results suggest that negotiating parties' enthusiasm to collar food aid shipments is not based on observable relationships between aid shipments and export subsidies or credit guarantees. A new WTO agreement would presumably establish new binding rules on export subsidies and credit guarantees, thus changing the institutional structure that underlies this investigation. However the lack of an historical relationship implies that the concern that food aid will be used as an alternative outlet may be exaggerated.

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EUROPEAN UNION'S PREFERENTIAL TRADE AGREEMENTS IN AGRICULTURAL SECTOR: A GRAVITY APPROACH

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ABSTRACT:

The European Union (EU) is the first target market for developing countries' and Least Developed Countries' agricultural exports. Preferential trade agreements, either reciprocal or not, play a central role in forming trade opportunities for numerous developing countries. Our objective is to measure the impact of eleven regional trade agreements (RTA) on European agricultural imports with an expanded gravity model. Also, in order to compare these RTAs and their effects we calculate the implied tariff equivalent. Results indicate that a large number of EU's RTAs support the agricultural exports of developing countries to the EU market. Thus, RTAs are generally an attractive alternative for countries wishing to speed up the move towards multilateral free trade in agriculture. Nevertheless, two most important and unilateral RTAs (Generalized System of Preference expanded by Everything But Arms) and the agreement with Mexico have the negative effect over agricultural exports to EU. We attempt to explain the reasons of their failure.

JEL classification: C10, F10, F15
Keywords: preferential trade agreements, gravity model, implied tariff equivalent, agricultural sector, LDCs, EU.

1. INTRODUCTION

Developing countries mostly claim that their market shares in developed market remain limited, in spite of complex and sometimes extensive preferential access granted by rich countries to them. In particular, there are special regional trade agreements (RTAs) which permit to access easily to the rich countries markets. Those claims have been an important

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component of the arguments of developing countries in the recent trade liberalization talks and these argumentations over agricultural goods are more significant. The World Trade Organization (WTO) reports that the share of Least Developed Countries (LDCs) in total agricultural imports of Northern America was 2.6% in 1980 and 0.6% in 2000 in value. The corresponding figures for the Western Europe were 2.3% and 1.1%, Japan's figures were 1.4% and 0.9% (WTO (2001)).

The European Union (EU) is the biggest agricultural market in the world and has approximately 20% of total exports and imports of agricultural products during 1980-2004 (FAOSTAT online database). For the same period, the other big agricultural products importers like US, Japan, China, Canada and India had respectively 7.6%, 9.3%, 4.6%, 2.1% and 0.43% of the total value of agricultural goods imported in the world (author's calculation based on FAOSTAT online database). The EU is definitely an important target market for developing countries' and LDCs' agricultural exports in general and it is especially important for most former colonies of EU member states. The EU's trade preferences are thus potentially an important opportunity to increase the EU's market access. Actually, preferential trade agreements, either reciprocal or not, play a central role in forming trade opportunities for numerous developing countries, remarkably for the poorest ones. But EU's trade policy is fairly complex, and many trade partners benefit from various preferential agreements. For example, sub-Saharan Africa poor countries benefit from the Everything But Arms (EBA) program and the Cotonou agreement simultaneously. Moreover, EU has agreements with developed countries like the US. The analysis of the preferences must therefore be adapted to this specific context, where in addition the administrative requirements and the rules of origin vary from one agreement to the other, included for a given partner. The consideration of a given preferential arrangement cannot be properly studied without taking into account whether an alternative preferential arrangement is offered or not to the exporters. It justifies the interest to take a broad view of preferential agreements offered by the EU, whether reciprocal or not.

So this study tries to explain whether EU's preferential trade agreements improve the EU's agricultural market access for developing countries especially for LDCs or not. Our objective in this research is to measure the impact of eleven RTAs on European agricultural imports with special attention to LDC countries.

In that prospect, the gravity model is a good candidate. It has performed remarkably well as an empirical framework for measuring the impact of RTAs (for example see Frankel and Wei (1993), Frankel, Stein and Wei (1995), Finger, Ng and Soloaga (1998)). We follow the method of Anderson and van Wincoop (2003) and develop it to provide new results focusing on the EU's agricultural market access. Commonly, the gravity models are applied to aggregate data and they are used for the whole of an economy (e.g. see Aitken (1973), Thursby and Thursby (1987), Bergstrand (1989), Frankel, Stein and Wei (1993), Krueger, (1999), Soloaga and Winters (2001) Greenaway and Milner (2002), Ghosh and Yamarik (2004a, 2004b), Elliott and Ikemoto (2004), Mayer and Zignago (2005), Lee and Park (2005), Carrère (2006)). Jayasinghe and Sarker (2008) with gravity modelling using disaggregate data find the positive effects for NAFTA (North American Free Trade Agreement) in trade of selected agricultural products.

We apply the gravity model to a group of less aggregated goods (i.e. the agricultural sector). This is made possible by the construction and use of a new database extending the Trade and Production database recently issued by the COMTRADE (Commodity Trade

Statistics of United Nation) and WB (World Bank) data to cover more countries and years. A specific characteristic of our study is to identify in the border effect measurement of trade volume, the part associated with observed direct protection (RTAs, common border, common language etc.). We incorporate dummy variables capturing the lower (or higher) impact of borders on trade inside each RTA, and thus characterizing the extent of integration of the zone, compared to trade taking place in the rest of the sample. We identify eleven actual EU's RTAs defined in Table a1 in Appendix. Since the evaluation of EU's RTAs is complex and ambitious, we calculate the implied tariff equivalent of EU's RTAs to simplify the comparison of RTAs and their effects. In other words, we try to show the effect of RTAs like a reduction (or increase) in import tariff.

The remainder of the paper is organized as follows. Section 2 reviews the European preferential trade agreements in agricultural field. Section 3 motivates the methodology. It describes the modified gravity approach for agricultural sector of EU. Data and results are reported in section 4 and the final section concludes.

2. EU's Preferential Trade Schemes

Undoubtedly, the EU is the first supplier of trade agreements worldwide, with more than 50 RTAs (WTO discussion papers (2007)). According to WTO (2007), the EU with 14 *north-south RTAs*[1] in goods is the first supplier among developed countries in 2006. It is followed by the US with 8 RTAs, Canada and Australia with 4 RTAs each one, Japan and New Zealand with 3 RTAs. As illustrated by Figure 1 in Appendix, even a simplified overview of the EU's trade policy remains quite complex. The political economy roots of this profusion of agreements belong to the heterogeneity of the EU, to the specific role-played by its trade policy and by the strong demand from trading partners (Sapir (1998), Lamy (2002) and Panagariya (2002)).

From the beginning two kinds of RTAs must be distinguished, reciprocal and unilateral. First, RTAs are bilaterally agreed with reciprocal commitments between the members. Second, non-reciprocal agreements are unilaterally granted by the EU to developing countries or LDCs. While the first kind is planned to be a tool of regional economic integration, the second allowances more favourable market access to developing countries. Since the non-reciprocal agreements can be unilaterally changed, the nature of them involves uncertainty on the future. These numerous agreements can be also classified in a few categories. A first set includes close neighbourhood, reciprocal agreements within Europe, with in particular the EEA (European Economic Area) agreement, bilateral free-trade agreements with Central and Eastern European Countries (CEECs) untitled EU-Enlargement, and a few additional bilateral agreements like Euromed (Figure 1 in Appendix). For more details about the EU's RTAs, the date of sign and their member states, see Table a1 in Appendix.

Most of EU's preferential trade agreements with developing countries and LDCs are non-reciprocal. EU programs include the *Generalized System of Preferences* (GSP) program, which contains a special scheme for developing countries and LDCs known as the "*Everything But Arms*" Agreement (EBA); the *Cotonou* agreement with Africa, Caribbean and Pacific countries (ACP); and the *Euro-Mediterranean* agreements (EMA). The EU wants

[1] The RTAs between developed countries and developing countries or LDCs.

to help the poorest countries to increase their agricultural market access. Therefore, the EU has adopted an "*Everything but Arms*" (EBA) proposal that gives the LDCs duty-free and quota-free access for over 900 agricultural products with a limited preferential margin for so-called sensitive products.

The GSP is characterized by its temporary nature, with periodical revisions. Graduation measures are taken when beneficiary countries may have reached, in some sectors, a level of competitiveness that makes sure further growth without preferential access to the EU market (Candau and Jean (2005)). The GSP is associated with relatively stringent rules of origin. A special and more beneficial regime has in the past been granted to countries fighting drugs [2] (Coulibaly and Fontagné (2004)). Nevertheless, the duration of the EBA is unlimited, but the Cotonou Agreement will end in 2020.

The EU actually began offering nonreciprocal tariff preferences in the 1950s, providing preferential market access to former EU colonies for a larger set of products than the GSP program. [3] These preferences were included in the first *Lomé Convention*, signed in 1975 with 46 countries. Lomé arrangements were continued and expanded every 5 years, as in 2000 it was named *Cotonou* agreement and the number of countries grew to 73. Recently, the EU has new negotiations with ACP countries in order to sign a new agreement entitled *Economic Partnership Agreements* (EPAs). The aim is to make a free trade area between the EU and the ACP countries. The problem of EPAs is that the non-reciprocal and discriminating preferential trade agreements offered by the EU are incompatible with WTO rules. Besides, the other difficulty of EPA scheme is the adaptation of EPAs with EBA agreement.

3. METHODOLOGY

3.1. International Trade Volume and Border Effects

Mayer and Zignago (2005) claimed, "International trade flows are not enough to measure international markets integration". This statement is based on the simple idea that two countries could be considered perfectly integrated if the national borders have no effect over the choice of consumers for their purchases and of producers for selling their products. In fact, it is summarized as the whole idea of the EU's Single Market that aims to eliminate the economic effects of national borders.

The degree of international fragmentation of market is measured by the evaluation of the impact of national borders. To measure it, we have to consider both international trade flows and domestic good flows to compare them. The gravity equation is the ideal candidate to reach this aim. Indeed, even in the absence of flows between sub-national regions, you can still measure the total volume of trade occurring within a country. For a specified sector, you can measure the value of goods shipped from a country to its own consumers if you remove the total exports to the overall production of the country. This observation can then be inserted in a bilateral trade equation, together with all the international flows. Our framework

[2] In 2001, only Central American and Andean Pact countries were concerned.

[3] These preferences have their roots in the *Treaty of Rome*, which established the European Economic Community (which later became the EU) in 1957 and provided for trading and other arrangements with former colonial territories. The European Development Fund was established to help the economic development of those former colonies.

also incorporates recent advances in the modelling of gravity equations (recent examples and surveys of those approaches include Feenstra (2003), Mayer and Zignago (2005) and Minondo (2007)).

The border effect methodology has an important advantage in the study of trade volume. It was indeed measured for many issues. Take as an example the attempts to measure the impact of EU membership on trade flows. Aitken (1973) is one of the first to have made such a study. Frankel and Wei (1993), Frankel (1997), Soloaga and Winters (2001) and Mayer and Zignago (2005) are recent examples of such works. The border effect measure is also a useful methodology because it captures all barriers to trade related to the existence of the national borders (like common langue, common frontier, technical barrier, non-tariff barriers, RTAs and so on) through their impacts on trade flows. Most of those impediments and barriers are hard to measure individually, so it is useful to consider them in a global picture. In the next section, we describe the theoretical gravity model and show the border effect.

3.2. A Gravity Model for EU Agricultural Sector

In order to estimate the effect of EU' RTAs on trade flows among EU and its trading partners we use the gravity model developed by Deardorff (1998) and Anderson and van Wincoop (2003) with Armington's (1969) hypotheses.

Like Armington (1969) we assume that all goods are differentiated by place of origin, the supply of each being fixed and the consumer demand being defined by a CES utility function. In 1979, Anderson presented a theoretical foundation for the gravity model based on CES preferences and on goods that are differentiated by region of origin. We also assume, in this paper, that the consumer follows a two-step budgetary procedure. In the first step, the importing country's consumers define the import demand, choosing between domestic and imported products, in order to satisfy the total demand. In the second step, the import demand is differentiated by country of origin. Because we analyze the access to the European market, we only focus on this second step on the budgetary constraint, under the assumption that the first one is already done and that the total demand of imports is already defined. Thus, at the second step, like Anderson and van Wincoop (2003) the representative consumer from country *j* (importing country) maximizes a utility function of CES type for the product *k* with the geographical repartition of its imports from country *i* (exporting country):

$$U_{jk} = \left[\sum_i b_{ik}^{\frac{1-\sigma}{\sigma}} q_{ijk}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where *j* denotes the importing country, *i* is its trading partners, and *k* the exchanged product.[4] q_{ijk} is the quantity of product *k* originating from country *i* consumed in country *j*, and σ is the

[4] In this study, we suppose that *k* represents the sum of agricultural goods i.e. the total value of agricultural goods of country *i* exported to country *j*. Anderson and van Wincoop (2003) have applied their model for the whole economy, so their model is based on total GDP. Here, we use their model for the agricultural sector. Thus, we have introduced the *k* index for this sector and we use agricultural GDP.

elasticity of substitution between exporting countries (σ ≠ 1). The consumer in country *j* maximizes its utility subject to the budget constraint:

$$Y_{jk} = \sum_i p_{ijk} \; q_{ijk} \tag{2}$$

where Y_{jk} is the total expenditure of *j* for the imported product *k* and is defined in the first step of budgetary procedure. p_{ijk} is the price of product *k* from country *i*, paid by consumer in country *j*. p_{ijk} differs from exporter's supply price p_{ik} due to trade costs, which are not directly observable. Trade costs are broadly defined to include all costs incurred in getting a good to a final user other than the production cost of the good itself.

Assuming that trade costs are born by sellers and taking the "iceberg" form, the consumer price received by sellers in *i* (Anderson and van Wincoop, 2003) is:

$$p_{ijk} = p_{ik} \; t_{ijk} \tag{3}$$

where t_{ijk} is the bilateral trade resistance (or in other words trade costs factor) for which the assumption was made that it encompasses tariffs, transport costs (proxied by distance), non-tariff barriers and other factors (they will be listed after).

Solving the consumer utility function (1) subject to the budget constraint (2) leads to the following equation:

$$X_{ijk} = p_{ijk} \; q_{ijk} = Y_{jk} \left(\frac{b_{ik} \; p_{ik} \; t_{ijk}}{\overline{P}_{jk}} \right)^{1-\sigma} \tag{4}$$

where $\overline{P}_{jk}$ refers to country *j*'s CES price index for product *k*, related to *j*'s overall import price of product *k*. So the consumer price index for product *k* is computed as:

$$\overline{P}_{jk} = \left[\sum_i \left(b_{ik} \; p_{ik} \; t_{ijk} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{5}$$

Anderson and van Wincoop (2003) use market clearance condition (country *i*'s income should equal the value of its exports plus the value of the production sold in the domestic market), and assume that trade barriers are symmetric, i.e. $t_{ij} = t_{ji}$. These assumptions allow, firstly, to define each country's consumers price index as a function of partners countries price indexes and trade barriers:

$$\overline{P}_{jk}^{1-\sigma} = \sum_i \theta_{ik} \left(\frac{t_{ijk}}{\overline{P}_{ik}} \right)^{1-\sigma} \tag{6}$$

where θ_{ik} is country i's share in the world income (Y_k^w) of product k ($\theta_{ik} \equiv \frac{Y_{ik}}{Y_k^W}$). Anderson and van Wincoop (2003) refer to consumer price indexes as multilateral resistance, as they depend on all bilateral resistances.

Secondly, a gravity equation is derived:

$$X_{ijk} = \frac{Y_{ik}\ Y_{jk}}{Y_k^W} \left(\frac{t_{ijk}}{\overline{P}_{jk}\ \overline{P}_{ik}} \right)^{1-\sigma} \tag{7}$$

where Y_{ik} is the total income of country i for the product k, $\overline{P}_{jk}$ the consumer price index for product k in country j and $\overline{P}_{ik}$ is the consumer price index for product k in country i.

Then equation (7) is called gravity equation. As in traditional gravity equations, trade is supposed to depend positively on the size of each country and negatively on a trade barrier factor. But here, trade is also affected by the price indexes of both countries.

The next step is to model trade costs. Anderson and van Wincoop (2003) assumed in their model that the trade cost factor consists on two terms corresponding to two different types of costs: non-border costs (d), national border effects (bor) i.e.:

$$t_{ijk} = d_{ij}^{\rho}\ bor_{ij} \tag{8}$$

They showed the border effect only with one dummy variable, i.e. if two countries are the same border bor_{ij} is equal to 1, and 0 otherwise. But the common border effect is also affected by other factors like colony (*Col*), regional trade agreements (*RTA*) between two countries' i and j. Consequently we define the border effects by:

$$bor_{ij} = e^{\theta_1\ B_{ij} + \theta_2\ Col_{ij} + \theta_3\ L_{ij} + \theta_4\ Land_{ij} + \theta_5\ RTA_{ij}} \tag{9}$$

where B_{ij} is a dummy variable equal to 1 if countries i and j have common border and 0 otherwise, Col_{ij} is a dummy variable equal to 1 if countries i are the ancient colony of countries j and 0 otherwise, L_{ij} is a dummy variable equal to 1 if countries i and j speak a common language and 0 otherwise, $Land_{ij}$ is a dummy variable equal to 1 if countries i are in landlocked group countries, RTA_{ij} is a dummy variable equal to 1 if both countries i and j are members of the RTA and 0 otherwise. As a result we redefine the trade cost by:

$$t_{ijk} = d_{ij}^{\rho}\ \exp[\theta_1 B_{ij} + \theta_2 Col_{ij} + \theta_3 L_{ij} + \theta_4 Land_{ij} + \theta_5 RTA_{ij}] \tag{10}$$

Transforming equation (7) in log terms and replacing the trade cost factor with equation (10) yields:

$$\ln(X_{ijk}) = -\ln(Y_k^W) + \ln(Y_{ik}) + \ln(Y_{jk}) - (1-\sigma)\ln(\overline{P}_{ik}) - (1-\sigma)\ln(\overline{P}_{jk}) + (1-\sigma)\rho\ln(d_{ij}) + (1-\sigma)\theta_1(B_{ij}) + (1-\sigma)\theta_2(Col_{ij}) + (1-\sigma)\theta_3(L_{ij}) + (1-\sigma)\theta_4(Land_{ij}) + (1-\sigma)\theta_5(RTA_{ij}) + e_{ijk} \quad (11)$$

where X_{ijk} is the nominal value of agricultural exports from exporting countries *i* (here EU's trading partners) to the importing country *j* (here EU), Y_k^W is the world GDP of agricultural sector, Y_{ik} is the agricultural GDP in exporting country *i*. Y_{jk} is the agricultural GDP in importing country *j*, $\overline{P}_{ik}$ refers to export price index of exporting country *i*, $\overline{P}_{jk}$ refers to import price index of importing country *j*, d_{ij} is the distance between capitals of country *i* and country *j*.

Therefore, for total agricultural products, the equations (12) and (13) are estimated by using panel data for the EU agricultural sector.

$$\ln(X_{ijk}) = a_0 + a_1\ln(Y_{ik}) + a_2\ln(Y_{jk}) + a_3\ln(\overline{P}_{ik}.\overline{P}_{jk}) + a_4\ln(D_{ij}) + a_5(B_{ij}) + a_6(Col_{ij}) + a_7(L_{ij}) + a_8(Land_{ij}) + \sum_r \gamma_r(RTA_{rij}) + e_{ijk} \quad (12)$$

$$\ln\left(\frac{X_{ijk}\,Y_k^W}{Y_{ik}\,Y_{jk}}\right) = b_0 + b_1\ln(\overline{P}_{ik}\,\overline{P}_{jk}) + b_2\ln(D_{ij}) + b_3(B_{ij}) + b_4(Col_{ij}) + b_5(L_{ij}) + b_6(Land_{ij}) + \sum_r \theta_r(RTA_{rij}) + e_{ijk} \quad (13)$$

Although in traditional gravity equation (equation (7)) the coefficients of income variables (Y_{ik}, Y_{ij} and Y_k^W) equal one, most of empirically studies relax this restriction and estimated general form (equation (12)) (For example see McCallum (1995), Ghosh and Yamarik (2004a, 2004b) and Carrère (2006)). Also, the restricted form, with the income coefficient equal to one (equation (13)), was used in some studies (e.g. Anderson and van Wincoop (2003)). In this study, both forms (equations (12) and (13)) are estimated.

The aggregate prices ($\overline{P}_{ik}$ *and* $\overline{P}_{jk}$) mostly are not accessible so many researchers suggested to proxy them. Traditionally, remoteness variables are used, which are presumed to reflect the distance of a country from its alternative trading partners (for example, Wei (1996), and Anderson and van Wincoop (2003)).We substitute the price indexes terms by two types of proxy. First, price indexes terms are proxied by FAO indices for total agricultural products. These value indices represent the change in the current values of export (f.o.b.) and of import (c.i.f.), all expressed in US dollars. $\overline{P}_{jk}$ is substituted by "import value index" (IM_j) and $\overline{P}_{ik}$ is substituted by "export value index" (EX_i). Therefore, this new variable (PI) is defined by:

$$PI = EX_i\ IM_j$$

Second, like many researchers (e.g. Wei (1996), Anderson and van Wincoop (2003)) we substitute the price index terms with remoteness variable, which is supposed to reflect the distance between a country and its trading partners. This variable represents bilateral distances weighted by GDP with alternative trading partners. It is defined as follows:

$$RIM_i = \sum_{m \neq j} \frac{D_{im}}{Y_{mk}}$$

where country *m* is an alternative trading partner (or the other target markets for country's *i*), D_{im} is the distance between country's *i* and *m*, Y_m is the income of country *m* in the sector of *k*. US and Japan constitute approximately 20% of world agricultural imports. Hence, we consider these countries like alternative trading partners. Consequently, *m* refers to these two countries.

We expect to find a positive sign for RIM_i. If the country's *i* is far from the alternative target markets, there are more chance to export to the EU. Also, if the countries' *m* are rich the opportunity of exporting towards EU decreases because these alternative trading partners buy more products from countries *i*.

4. DATA AND ESTIMATIONS

4.1. Data Description

The values of imports (total agricultural sector) are collected from Commodity Trade Statistics of United Nation (COMTRADE) for 5 years from 2000 to 2004. The Agricultural GDP and population are collected by World Bank (WB) data. During this period, the total agricultural imports are considered for the EU with 15 member states. The system of classification SITC (Standard International Trade Classification) has 1-digit code for the agricultural sector. Trade and agricultural GDP are expressed in US dollar ($). Distances between the capitals (by kilometres, Brussels is supposed to be the capital of the EU) and dummy variables (common border, common language, landlocked countries, and ancient colony) are collected with the CEPII data file. 167 countries (all EU's trading partners) are considered (Table a2 in Appendix). The "export value index of agricultural goods" for exporting countries (country *i*) and the "import value index of agricultural goods" for importing countries (country *j*, here the EU) are collected with the FAOSTAT database.

The examined trade agreements are the following: African-Caribbean and Pacific States (COTONOU), Generalized System of Preferences (GSP), Everything But Arms (EBA), European Economic Area (EEA), European Union-Chile Association Agreement (EUCAA), Central and Eastern European Countries or EU-Enlargement (EUEN), Euro-Mediterranean Agreement (Euromed), European Union Caribbean Economic partnership agreement (EU/Caraibbean-EPA) is a new agreement with Central American Common Market countries (CACM) and Andean Group (ANDEAN), Mexico-European Union Free Trade Agreement (MEUFTA) and Trade Development Cooperation Agreement with South Africa (TDCA) (for more details about EU's RTAs see Table a1 in Appendix).

4.2. Econometric Results

Table 1 reports the econometric results from equations (12) and (13), based on the specifications discussed above (columns 1 and 3 correspond to the estimation with *RIM* as a price proxy and columns 2 and 4 correspond to the estimation with *PI* as a price proxy). According to this table, the implied income elasticity (agricultural GDP for exporting countries $LnYAG_i$) is positive and significant in all cases. The positive effect for exporter countries ($LnYAG_i$) shows that the high- agricultural income countries export more.

Table 1. Results of gravity models (with panel data) for EU (2000-2004)

	Variables	(1) Eq. 12		(2) Eq. 12		(3) Eq. 13		(4) Eq. 13	
		Coefficients	t-values	Coefficients	t-values	Coefficients	t-values	Coefficients	t-values
	$LNYAG_i$	0.88*	92.35	0.88*	92.08	---	---	---	---
	$LNYAG_{EU}$	1.04*	2.89	-0.34	-0.68	---	---	---	---
	LNPI	---	---	0.44*	4.08	---	---	0.63*	5.93
	LNRIM	0.83*	7.81	---	---	0.60*	2.70	---	---
	LNDIS	-0.15*	-9.09	-0.13*	-12.93	-0.18*	-10.30	-0.17*	-14.90
	BOR	1.62*	19.26	1.65*	15.26	1.64*	17.77	1.63*	13.54
	LAND	-0.97*	-15.86	-0.94*	-14.36	-1.00*	-14.07	-0.94*	-14.28
	LANG	1.04*	13.47	1.01*	14.43	1.01*	12.71	0.98*	14.70
	COL	1.19*	23.33	1.28*	24.98	1.22*	21.11	1.30*	24.77
	GSP	-0.73*	-12.73	-0.74*	-15.67	-0.61*	-11.07	-0.62*	-14.46
RTAs	EBA	-1.38*	-5.04	-1.32*	-4.76	-1.27*	-4.08	-1.31*	-4.66
RTAs	COTONOU	0.64*	6.30	0.73*	6.74	0.86*	7.33	0.98*	8.71
RTAs	EUROMED	-0.05	-1.40	0.004	-0.12	-0.03	-0.69	-0.01	-0.30
RTAs	EEA	2.84*	35.26	2.79*	37.36	2.96*	36.82	2.92*	40.39
RTAs	EUEN	0.56*	4.98	0.53*	4.97	0.69*	6.14	0.66*	6.39
RTAs	CACM	1.11*	13.39	1.23*	25.11	1.21*	15.23	1.33*	34.31
RTAs	ANDEAN	0.52*	9.57	0.71*	12.66	0.56*	7.78	0.71*	11.37
RTAs	TDCA	1.22*	11.83	1.12*	10.66	0.93*	7.75	0.77*	7.81
RTAs	MEUFTA	-1.41*	-36.16	-1.32*	-37.04	-1.70*	-49.22	-1.65*	-58.51
	EUCAA	1.40*	3.04	1.74*	2.91	1.64*	3.77	1.71*	3.00
	CONSTANT	-15.35	-1.60	4.02	0.31	60.23*	17.26	44.95*	45.07
	R^2	0.60		0.60		0.36		0.38	

* denotes significance at the 5% level

Note: the results are shown after correction of heteroscedasticity.

YAGi = the agricultural GDP of exporting country, *YAGeu* = the agricultural GDP of importing country (EU), *PI*= the price indexes, *RIM*= the remoteness variable, *DIS* = the distance between the capitals, *BOR* = common border, *LAND* = landlocked group countries, *LANG* = the same language, *COL* = the ancient colony of countries *j*, *RTA* = Regional Trade Agreement.

Besides, the magnitudes of these estimates are similar to those found in the literature for all tradable goods (for example in Anderson and van Wincoop (2003)'s and Carrère (2006)'s papers, it is around 1.10 and in Ghosh and Yamarik (2004a) it is 0.90). As this coefficient for agricultural sector is smaller (0.88), it confirms the results of Feenstra et al. (2001). They estimated gravity equations in three cases (export of differentiated goods, export of reference priced goods and export of homogenous goods): their results show that the income elasticities (coefficients of GDP) for homogenous goods are less than other types.

The EU's agricultural GDP ($LnYAG_{EU}$) is significantly positive when the equation is estimated with the remoteness variable (column 1). It shows that the exports of agricultural products increase with increase in the EU's agricultural GDP. Results concerning the distance show the negative effect over import of agricultural products but this coefficient is less than the estimates found in the literature for all tradable goods. For example, McCallum (1995), Feenstra et al. (2001) and Anderson and van Wincoop (2003) find this coefficient is around one. Although these studies consider entire tradable goods, Feenstra et al. (2001)'s found when they use the homogenous goods that distance coefficients decrease (it is around 0.7). Here we find the same signal: using data of agricultural sector increases the degree of homogeneity. In addition, this may reflect the fact that many agricultural products are shipped by huge transportation.

The common border, landlocked countries, common language and EU's old colonies coefficients have the expected sign and are significant at 5% level. The agreements of COTONOU, EEA, EUEN, CACM, ANDEAN, TDCA and EUCAA show positive and significant effect over exports of agricultural commodities to EU market and GSP, EBA and MEUFTA show negative and significant effect at 5% level. The sign associated with Euromed agreement is not statistically significant. The estimates for each RTA are briefly discussed below.

In order to better compare the EU' RTAs, we calculate the implied tariff equivalent with different substitution elasticities (σ). Table 2 shows the implied tariff equivalent for the EU's RTAs subject to three rates for substitution elasticity ($\sigma = 2, 5, 10$).

The coefficient for COTONOU agreement (between ACP countries and EU) shows positive effects in all cases in Table 1. Using a substitution elasticity, it is possible to calculate the implied tariff equivalent of the per-RTA border cost for all agricultural commodities. As an example, suppose an elasticity of substitution (σ=10) and the estimated border effect coefficient of COTONOU agreement from the first estimation (0.64), so the tariff equivalent of this agreement is 7 percent [$=100 \times (\exp[0.64/(1-10)]-1)$] (for more details see Appendix 2). With a substitution elasticity of 5 (σ=5) the per-RTA border is 15 percents. A similar pattern emerges for the imports of agricultural commodities from EEA, EUEN, CACM, ANDEAN, TDCA and EUCAA. Most of EU's RTAs are similar to a decrease in the tariff, except the three important RTAs (GSP, EBA and MEUFTA) for poor countries and developing countries that are equal to an increase in tariff (Table 2). Namely, the GSP, EBA and MEUFTA increase respectively by 20%, 41% and 42% the tariff (if σ =5, based on first estimation) for trade in all agricultural commodities. In other words, the GSP, EBA and MEUFTA show the negative effect over trade (Table 1). Because most of countries in these agreements are LDCs it may show that LDCs do not necessarily have a strong comparative advantage in agriculture products. In addition, it maybe shows that these kinds of RTAs (they are unilateral and they do not cover all agricultural products) are not so useful for LDCs countries.

Table 2. The implied tariff equivalent (%) of the EU's Per-RTA with trade blocs

	(1)			(2)			(3)			(4)		
σ ⇨	2	5	10	2	5	10	2	5	10	2	5	10
GSP	108*	20*	8*	110*	20*	9*	84*	16*	7*	86*	17*	7*
EBA	297*	41*	17*	274*	39*	16*	256*	37*	15*	271*	39*	16*
COTONOU	-47*	-15	-7*	-52*	-17*	-8*	-58*	-19*	-9*	-62*	-22*	-10*
EUROMED	5	1	1	0	0	0	3	1	0	1	0	0
EEA	-94*	-51*	-27	-94*	-50*	-27*	-95*	-52*	-28*	-95*	-52*	-28*
EUEN	-43*	-13*	-6*	-41*	-12*	-6*	-50*	-16*	-7*	-48*	-15*	-7*
CACM	-67*	-24*	-12*	-71*	-26*	-13*	-70*	-26*	-13*	-74*	-28*	-14*
ANDEAN	-41*	-12*	-6*	-51*	-16*	-8*	-43*	-13*	-6*	-51*	-16*	-8*
TDCA	-70*	-26*	-13*	-67*	-24*	-12*	-61*	-21*	-10*	-54*	-18*	-8*
MEUFTA	310*	42*	17*	274*	39*	16*	447*	53*	21*	421*	51*	20*
EUCAA	-75*	-30*	-14*	-82*	-35*	-18*	-81*	-34*	-17*	-82*	-35*	-17*

* Significant at the 5% level

Finally, to take into account overlapped agreements, we completed the analysis. First we estimated the models with each RTA separately and we find the same results considering the sign and the magnitude of coefficients. Second, we keep the eleven RTAs but we divided EBA and Cotonou dummies. We so distinguished countries which participate only to the EBA agreement from those which participate only to the Cotonou agreement, and finally a dummy represents the case where countries participate to both. Results are reported in Table a4 in Appendix. We can notice that conclusions already expressed remain. The only exception concerns the case of Euromed. Indeed, this agreement shows positive and statistically significant effects. Nevertheless, this effect is not so surprising; it is also the result of some other studies (see for instance Peridy (2005)). We also run the estimations with and without the dummy for GSP but this last one does not change our results.

Let us know come back to the case of EBA. If the purpose of the EBA agreement is to provide increased market access through eliminating tariffs and quotas, it failed. Our calculation based on UN Comtrade database show that the market access of LDCs in the EU agricultural market from 3.0% decreased to 2.7% during the period of estimation (2000-2004). Also, Bureau et al. (2006) show that EBA had the smallest rate of utilization between EU's non-reciprocal preferences (in 2002 the rate of utilization of EBA was 17% whereas it was 92.8% for Cotonou) (also refer to Bureau et al. (2007)). Besides, the estimated results present a negative effect of this agreement over exports of EBA countries (Tables 1, 2). So, few questions emerge: why does this agreement failure? Alternatively, why is EBA agreement similar to an increase in import tariff? Since EBA is an important agreement, for LDCs let us briefly explain this agreement and mention some failure reasons.

EBA agreement and LDCs: The EBA agreement is an extension of the EU's Generalized System of Preferences (GSP) that was entered into force in 2001. This unilateral agreement gives to 49 LDCs [5] into the world zero tariffs with no quantitative restrictions on

[5] The 49 least developed countries are those categorized within the United Nations classification format as "least developed." The UN uses three criteria: low national income (under $900 GDP per capita); weak human

all products, except arms, without reciprocity. This agreement keeps out sensitive products including rice, sugar, and bananas. The EU preferential market access aspect of EBA aims to facilitate trade with the LDCs. The purpose of increased market access is to enhance trade with the aim to help the LDCs to expand their economies. Our data show that EU agricultural imports from the LDCs have been decreasing over the past years (2000-2004). In addition, the results of gravity model show the negative effect for this agreement. Few explanations can be found. First, the preferences under EBA are given in unlimited period and there is no guarantee for LDCs that their preferences will be retained. Second, the changes in standards and rules are not clear enough for LDCs. Third, the "rules of origin" [6] dictated by the developed countries in some cases are too complex, inflexible and they have massive administrative demands; in addition, it is often very costly to prove the origin.

The rules of origin restrictions in the EBA agreement are too restrictive and more than in the Cotonou Agreement. The rules of origin in the Cotonou agreement allow to the products to move within the ACP countries for supplementary processing before exporting to the EU. Although the original goods do not come from the ACP countries, they could still beneficiate the duty free access (Official Journal of the European Communities, L317/3 December 15, 2000). In addition, the rules of origin for fishing exports to the EU in the Cotonou agreement are much more flexible. To compare some of these rules between EBA and Cotonou see Table a3 in Appendix. The main explanation is that Cotonou agreement imposes less administrative constraints, or is more flexible regarding to the origin of the material used as inputs to exports than competing agreements. When exporters have the choice between two preferential agreements and one of them is more generous than others, they tend to favour particular agreements. Therefore, the members prefer exports under Cotonou agreement for using the preferences. In the other hand, the EBA members that are not included in the Cotonou agreement loose the competition to entrance in the EU market. These preferences are much criticized by many other studies (e.g. Brenton (2003), Panagaryia (2003), Ozden and Reinhardt (2003) and Topp (2003)).

Finally, although EU's sanitary and phytosanitary (SPS) regulations and import standards are not actually part of any specific agreement and that they are applied equally to all countries, obtaining these standards still keeping a comparative advantage is not easy for the LDCs farmers. Producers in developed countries have the luxury of technology and other aids but the producers in LDCs do not have the ability to pay for achieving to these standards.

Furthermore, preferential trading arrangements can create an artificial comparative advantage due to the duty-free access into the market. Economic theory advises that the producers should allocate resources to their most efficient uses. Another negative aspect of the GSP and EBA preferences is that it no longer gives preferences to the same country in every sector. It could lead to a move from these sectors towards a beneficial one.

Mexico is a member of NAFTA (North American Free Trade Agreement). So, this country benefits a quota-free and duty-free to export to the USA and Canada for some agricultural products. The reduction of exports to the EU can probably be explained by more

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assets; and high economic vulnerability (an index measuring instability of agricultural production and exports, inadequate diversification, and economic smallness).

[6] The theory behind *rules of origin* is to avoid trade deflection (or re-export) from countries non-benefited from special preferences through another country benefited from preferences and into the final market in order to use the trade preferences given to the LDCs.

Mexico's exports under the NAFTA agreements. The consideration of the supply side needs more information and data.

5. CONCLUSION

The evaluation and the analyze of EU's RTAs are complex and ambitious. This paper investigates the potential impact of EU's RTAs on extra-trade flows. For this purpose, an expanded gravity model is used to estimate the impact of eleven RTAs (ten of them are with developing countries and poor countries) on trade patterns between EU and their trading partners. In order to compare these RTAs and their effects we calculate the implied tariff equivalent of EU's RTAs. In other words, the effect of RTAs is shown like a reduction (or increase) in import tariff.

The empirical analysis undertaken in this paper indicates that a large number of EU's RTAs support the agricultural exports of developing countries to the EU market. Thus, the EU's RTAs are often an attractive alternative for countries wishing to speed up the move towards multilateral free trade in agriculture. Nevertheless, we find the negative effect for two most important and unilateral RTAs (EBA and GSP) and the agreement with Mexico (MEUFTA).

The EU was the first to extend unilateral trade preferences to the LDCs, to engage in more trade with EBA countries than does any other country in the world. The aim of EBA agreement is an aid for economic growth and stability for the LDCs with increasing market access to the EU. Therefore, it would be expected that the EBA agreement would increase the agricultural market access for EBA countries because of duty-free market access. Nevertheless results of our estimations over the period 2000-2004 show that the EBA had the negative effect over the exports of EBA countries to EU market. Rigorous rules of origin, in terms of rigid cumulation rules, substantial processing and transport regulations are maybe some significant causes of the failure of this agreement. Furthermore, SPS regulations and heavy import standards can also largely decrease the exports to the EU. Also in EBA, the stability of preferences is not guaranteed. Additionally, another disadvantage of these unilateral preferences is that countries easily become dependent on the preferences and focus their economy around one product rather than allocating resources throughout the economy. Nevertheless, the main explanation is that Cotonou agreement and EBA are overlapped and Cotonou imposes less administrative constraints. So when exporters have the choice between two preferential agreements and if one of them is more generous than others, they tend to favour particular agreements.

Recently, the EU has new negotiations with ACP countries for signing a new agreement entitled the Economic Partnership Agreements (EPAs). EPAs are a scheme in order to make a free trade area between the EU and the ACP countries. The problem of EPAs is that the non-reciprocal and discriminating preferential trade agreements offered by the EU are incompatible with WTO rules. "How trade must be liberalized under the new EPAs" is still an extensively debated issue. Currently, the United Nations define 39 of the ACP countries as LDCs. As opposed to the other ACP countries, the group of LDCs will be asked to reject the EPAs and continue trade relations under the EBA regulation. While this provision facilitates the situation of the LDCs under the new trade scheme, it has also been criticised that the EBA initiative.

Already we mentioned that Cotonou (last agreement with ACP countries) overlap the EBA agreement and countries prefer to export to EU under Cotonou agreement. But, all LDC countries are not in the Cotonou agreement. Most of these countries are very poor countries and have not barging power in negotiations with EU. According to our results and mentioned arguments above, the authors suggest that EU has to take into account the problem of overlapped agreements and if EU wants that agreements do not neutralize together, it has to separate them. Especially, LDCs could be taken into account in separated groups and some agreements could be made with these countries. Accordingly, the authors suggest that EU has to modify these agreements if the EU aims to help poor countries.

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APPENDIX 1:

Table a1. The agreements between EU and the other trade blocs

Regional Trade Agreement	**Members**	**The date of sign**	**Reciprocal (+) or Nonreciprocal (-)**
Cotonou (with ACP African-Caribbean and Pacific Group of States)	Angola, Antigua and Barbuda, Bahamas, Barbados, Belize, Benin, Botswana, Burkina Faso, Burundi, Cameron, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Cook Islands, Cuba, Dominica, Dominican Republic, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Federated States of Micronesia, Fiji, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, , Grenada, Guyana, Haiti, Jamaica, Ivory Coast, Kenya, Kiribati, Lesotho, Liberia, Marshall Islands, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Nauru, Niue, Palau, Papua New Guinea, Rwanda, Samoa, Solomon Islands, Sao Tome & Principe, St.-Kitts &	2000	+

	Nevis, St.-Lucia, St.-Vincent, Suriname, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Trinidad & Tobago, Timor-Lets, Tonga, Tuvalu, Uganda, Vanuatu, Zambia, Zimbabwe.		
ANDEAN = (CAN) Andean Group	Bolivia, Colombia, Ecuador, Peru, Venezuela	1996	+
CACM = Central American Common Market countries	El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica	1961	+
EBA = Everything But Arms	Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cape Verde, Chad, Comoros, Ctrl.-Africa-Rep., Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Eq., Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Nepal, Niger, Rwanda, Samoa, Sao, Sierra Leone, Solomon-Isl., Somalia, Sudan, Tanzania, Togo, Tome, Tuvalu, Uganda, Vanuatu, Yemen, Zambia.	2001	-
EEA = European Economic Area	Iceland, Liechtenstein, Norway	1994	+
EUCAA = European Union-Chile Association Agreement	Chili.	2002	+
EUEN = Central and Eastern European Countries or EU-Enlargement	Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia	2004	+
EUROMED = Euro-Mediterranean Agreement	Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestinian Authority, Syria, Tunisia, Turkey.	1995	+
GSP = Generalized System of Preferences	All developing countries	1971, 2006 (new GSP)	-
MEUFTA = Mexico-European Union FTA	Mexico	2000	+
TDCA = Trade Development Cooperation Agreement with South Africa	South Africa	1999	+

Table a2. The list of trade partners (167 countries):

Albania	Congo-Dem. Rep	Indonesia	Mozambique	Slovenia
Algeria	Congo	Iran	Myanmar	Solomon Islands
Angola	Costa Rica	Iraq	Namibia	Somalia
Antigua & Barbuda	Cote d'Ivoire	Israel	Nepal	South Africa
Argentina	Croatia	Jamaica	New Caledonia	Sri Lanka
Armenia	Cuba	Japan	New Zealand	Sudan
Aruba	Cyprus	Jordan	Nicaragua	Suriname
Australia	Czech Rep.	Kazakhstan	Niger	Swaziland
Azerbaijan	Djibouti	Kenya	Nigeria	Switzerland
Bahamas	Dominica	Kiribati	Norway	Syria
Bahrain	Dominican Rep.	Rep. of Korea	Oman	Tajikistan
Bangladesh	Ecuador	Kuwait	Pakistan	Tanzania
Barbados	Egypt	Kyrgyzstan	Panama	Thailand
Belarus	El Salvador	Lao	Papua New Guinea	Togo
Belize	Equatorial Guinea	Latvia	Paraguay	Tonga
Benin	Eritrea	Lebanon	Peru	Trinidad & Tobago
Bhutan	Estonia	Lesotho	Philippines	Tunisia
Bolivia	Ethiopia	Liberia	Poland	Turkey
Bosnia Herzegovina	Fiji	Libya	Qatar	Turkmenistan

Table a2. (Continued)

Botswana	French Polynesia	Lithuania	Romania	Uganda
Brazil	Gabon	Macedonia	Russian Federation	Ukraine
Bulgaria	Gambia	Madagascar	Rwanda	United Arab Emirates
Burkina Faso	Georgia	Malawi	Saint Kitts & Nevis	USA
Burundi	Ghana	Malaysia	Saint Lucia	Uruguay
Cambodia	Grenada	Maldives	Saint Vincent & the Grenadines	Uzbekistan
Cameroon	Guatemala	Mali	Samoa	Vanuatu
Canada	Guinea	Malta	Sao Tome & Principe	Venezuela
Cape Verde	Guinea-Bissau	Marshall Islands	Saudi Arabia	Viet Nam
Central African	Guyana	Mauritania	Senegal	Yemen
Chad	Haiti	Mauritius	Serbia & Montenegro	Zambia
Chile	Honduras	Mexico	Seychelles	Zimbabwe
China	Hungary	Moldova, Rep.	Sierra Leone	
Colombia	Iceland	Mongolia	Singapore	
Comoros	India	Morocco	Slovakia	

Table a3. The regulations in COTONOU and EBA agreements in fishing sector

Cotonou Agreement	EBA agreement
The vessel can be registered in the EU or in any ACP country, independent of which country the products are exported from.	The ship must be registered to the EU or the direct beneficiary country.
The vessel can sail under the flag of any ACP country or the EU.	The vessel must sail under the flag of the EU or the direct beneficiary country.
The master and officers along with 50 percent of the crew must be nationals of ACP countries or the EU.	The master and officers along with 75 percent of the crew must be from the beneficiary or the EU.

Source: Official Journal of the European Communities website

Table a4. Results of gravity models considering overlapped agreements (panel data, 2000-2004)

Variables	(1) Eq. 12		(2) Eq. 12		(3) Eq. 13		(4) Eq. 13	
	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
LNYAGi	0.91*	95.12	0.90*	92.67	---	---	---	---
LNYAGEU	1.10*	2.57	-0.39	-0.72	---	---	---	---
LNPI	---	---	0.48*	4.67	---	---	0.66*	6.06
LNRIM	0.85*	7.81	---	---	0.62*	2.70	---	---
LNDIS	-0.17*	-11.45	-0.15*	-15.34	-0.19*	-12.37	-0.18*	-15.62
BOR	1.96*	19.64	1.99*	16.56	1.95*	18.73	1.94*	15.06
LAND	-1.01*	-15.75	-0.97*	-14.00	-1.03*	-14.19	-0.96*	-13.89
LANG	1.24*	15.83	1.20*	17.77	1.19*	15.07	1.16*	18.47
COL	1.12*	23.05	1.21*	24.58	1.15*	20.71	1.23*	24.45
EBAonly	-0.26*	-3.64	-0.21*	-2.81	-0.10	-0.80	-0.09	-1.12
EBA&Cotonou	-1.02*	-3.27	-0.88*	-2.79	-0.72*	-2.20	-0.64	-1.95
COTONOUonly	0.85*	4.70	0.95*	5.01	1.06*	5.50	1.20*	6.30
EUROMED	0.17*	5.33	0.21*	7.11	0.18*	5.31	0.20*	6.38
EEA	3.50*	39.32	3.45*	47.12	3.52*	40.21	3.49*	50.34
EUEN	0.98*	10.74	0.96*	10.38	1.03*	10.99	1.01*	10.87
CACM	1.07*	15.53	1.19*	28.67	1.18*	18.76	1.31*	42.68
ANDEAN	0.46*	6.72	0.65*	9.48	0.53*	6.68	0.69*	9.42
TDCA	0.93*	5.83	0.81*	4.85	0.70*	4.10	0.52*	3.29

Table a4. (Continued)

MEUFTA	-1.55*	-39.94	-1.45*	-53.05	-1.75*	-40.15	-1.69*	-50.74
EUCAA	1.32*	3.01	1.66*	2.89	1.60*	3.76	1.68*	2.97
CONSTANT	-17.52	-1.54	3.78	0.27	59.87*	16.87	43.98*	42.35
R^2	0.61		0.61		0.38		0.39	

* significant at the 5% level

Note: the results are shown after correction of heteroscedasticity.

EBA_{only} = dummy variable equal to 1 if country *i* participates only to the EBA agreement, $COTONOU_{only}$ = dummy variable equal to 1 if country *i* participates only to the Cotonou agreement and $EBA_{\&}Cotonou$= a dummy which represents the case where country *i* participates to both agreements (EBA and Cotonou).

APPENDIX 2:

Consider a simplified semi-logarithmic regression equation of the form:

$$\ln(Y) = \alpha + \sum_s \beta_s \ln X_s + \sum_r \zeta_r D_r + \varepsilon_{ij}$$

$$\zeta_r = \kappa_r \ (1-\sigma)$$

where X_s represent continuous explanatory variables and D_r is a set of dummy variables. *s* is the number of explanatory variables and *r* is the number of dummy variables. The coefficient of a continuous variable is:

$$\beta_s = \frac{\partial \ln Y}{\partial \ln X_s} = \frac{\partial Y}{\partial X_s}\frac{X_s}{Y}$$

Thus, the coefficient of a continuous variable is the elasticity of *X* for a small change in the explanatory variable X_s. However, a dummy variable is a discontinuous variable and the derivative of *X* with respect to a small change in D_r does not exist. Instead, we can calculate the percentage change in *X* going from X_0 to X_1 for a discrete change in D_r from 0 to 1 as:

$$\left[\frac{Y_1 - Y_0}{Y_0}\right] = \left[\frac{\exp(\alpha + \sum_i \beta_i \ln X_i + \zeta \times 1 + \varepsilon_i) - \exp(\alpha + \sum_i \beta_i \ln X_i + \zeta \times 0 + \varepsilon_i)}{\exp(\alpha + \sum_i \beta_i \ln X_i + \zeta \times 0 + \varepsilon_i)}\right] * 100 = \left[\exp(\hat{\zeta}) - 1\right] * 100$$

Thus,

$$\text{implied tariff equivalent} = \left[\exp\left(\frac{\kappa_r}{1-\sigma}\right) - 1\right] * 100$$

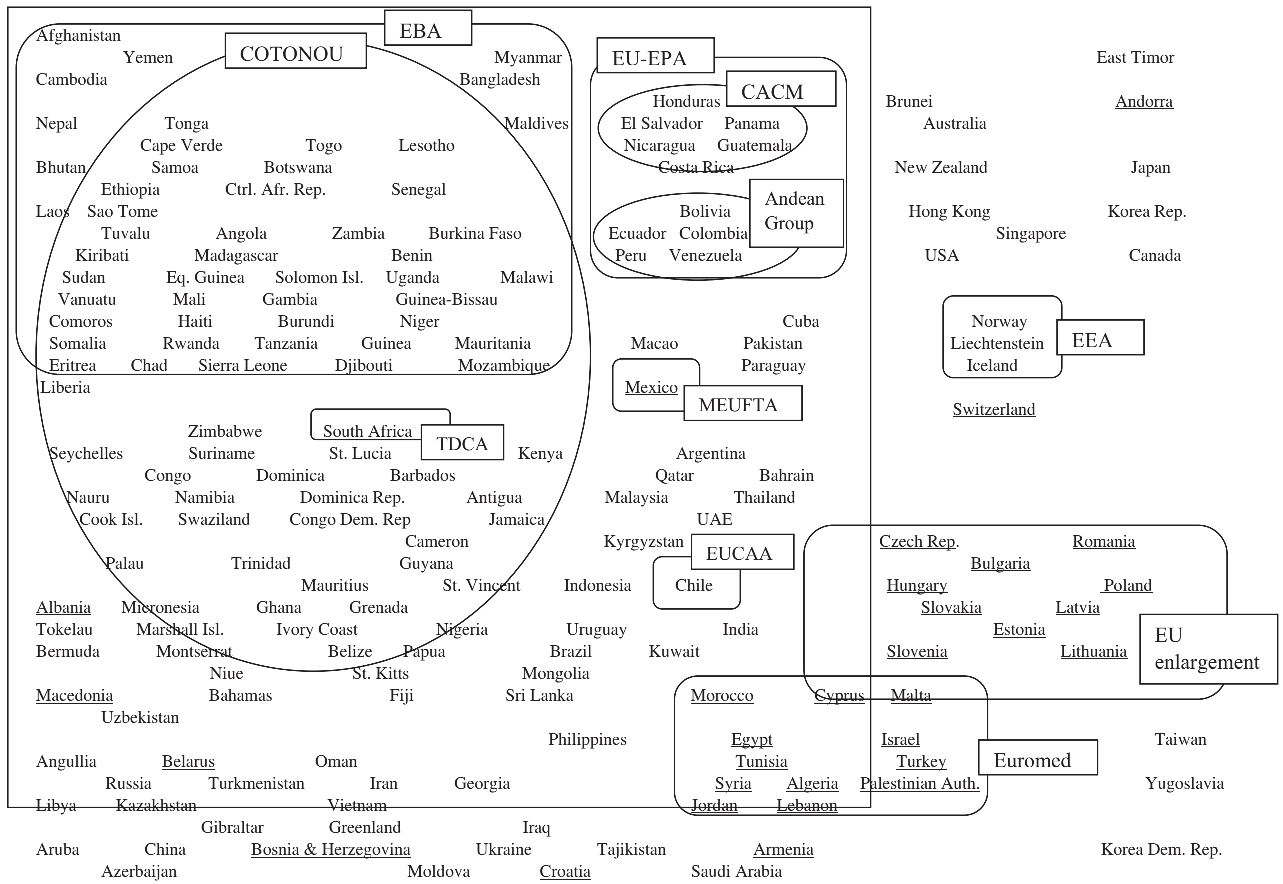

Figure 1. EU's trade agreements in 2004

Source: based on Bouët et al (2002), Candau and Jean (2005) and Bouët et al. (2005).

Note: The underlined countries have a bilateral agreement with EU.

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INTEGRATION IN BENIN MAIZE MARKET: AN APPLICATION OF THRESHOLD COINTEGRATION ANALYSIS

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ABSTRACT

Hansen and Seo's multivariate threshold cointegration model is used to characterize integration between selected maize markets in Benin immediately following the period of market liberalization and reform. Observed transaction costs for market pairs are compared with the estimated thresholds obtained from the multivariate model. We find strong evidence of threshold cointegration for some market pairings. In addition, we observe significant short-run price dynamics for these market pairings when price differentials exceed threshold levels. In contrast, our results reveal that short run price dynamics are insignificant or negligible when threshold levels exceed price differentials. This leads us to conclude that there is evidence of long run integration between at least some Benin maize markets and that prices in these markets quickly respond to large disequilibria (i.e. price differences between market pairings that exceed threshold transaction costs). However, transaction costs are large and hence price adjustments are relatively infrequent. Thus our results indicate that short run inefficiencies prevail even after liberalization. Although market liberalization reforms appear to have not been completely effective in terms of promoting quick price adjustments between markets during the period studied, our threshold results suggest that further policies designed to lower transaction costs could be effective at promoting market integration.

Key words: market integration, threshold cointegration, liberalization
JEL codes: R15, C32

INTRODUCTION

During the period from the 1970s to the 1990s, a number of African countries have tried to regulate their internal commodity market systems. These regulatory controls often involved regulation of quantities marketed, price control, the restriction on private traders' activities, and control of arbitrage and interregional trade. During the 1990s, deregulation and price

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liberalization policies were adopted in many countries. It was assumed that a free-market system would perform better than the government-controlled systems. In 1990, the Benin government also began a liberalization policy in grain markets and implemented several reforms. The government parastatal "Office Nationale des Céréales" (ONC) was abolished and new institutions were created to ensure a free market environment. Among them was the "Office Nationale de Securité Alimentaire" (ONASA) responsible for establishing a free market and competitive environment for traders. One of the most important policy actions implemented by this institution was the Market Information System (MIS). The MIS was designed to provide information on maize prices, market conditions and trading opportunities to all traders. The maize industry is an extremely important sector of Benin's agricultural economy, and maize is the primary source of food for Benin's population. Hence, the impact of market reforms on the marketing performance of the maize industry has always been of particular concern to the Benin government. To be able to efficiently manage reforms in the Benin maize industry, policy makers need a better understanding of the functioning of markets, and in particular price integration between markets. The present article investigates maize market integration in Benin over the post reform period 1998-2001 using a recently developed cointegration model that captures threshold transaction costs. As such, this type of modeling approach is well suited to investigating market integration in a developing country where transaction costs have traditionally been very large. The approach provides important insights with respect to the ability of regional Benin maize markets to respond to pricing signals in the presence of transaction costs that prevailed in the immediate post reform 1998-2001 period.

The remainder of the article is organized as follows. Section 2 presents a background of the functioning of the maize market in Benin and motivates the study. The Hansen and Seo (2002) two-regime threshold cointegration model and data are described in section 3 and 4, respectively. Results are presented and discussed in section 5, and section 6 concludes the article.

THE BENIN MAIZE MARKET

Benin's economy is essentially dependent on agriculture, and maize is the most important food crop. Maize is used in a variety of meals consumed by households.[1] In the south of Benin, maize represents the main food crop and it is mainly produced by farmers for their own consumption and for commercialization. In the north however, maize is mainly produced for commercialization and represents for farmers an alternative source of income besides cotton which is the main cash crop. Maize is produced in rural areas, often times in association or rotation with other crops such as: beans, peanut, cassava, cotton, yam, etc. It can be sold on local markets or regional markets. During harvest periods, maize may also be sold directly at the farm gate. Local markets are located in the vicinity of production zones (rural areas). The main agents of local markets are farmers, selling maize and/or other commodities to retailers and wholesalers. Regional markets are much bigger than the local

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[1] Maize flour is used to make dough, porridge, or cakes. The dough is widely consumed in Beninese households, often twice a day. It is accompanied with various types of sauces.

markets and they are located within city centers where a large number of consumers are concentrated. Wholesalers buy maize from the farm gate and local markets with the aid of collectors who help them to gather the commodity. The collectors live in production areas and hence have better knowledge of the availability of the commodity. They are remunerated by wholesalers and their commission depends on the quantity collected and whether or not the search conditions were good or bad.[2] Most of the maize collected from the farm gate and local markets is conveyed to regional markets and sold to retailers or directly to consumers.[3] In this article we focus on retail prices in these regional markets. The price of maize depends on the unit of measurement, which may vary from one market to another. Wholesalers and regional markets play an important role in the marketing system by assuring the supply and demand of the commodity: wholesalers assure the supply of maize by moving the commodity from the farm gate and local markets to regional markets, while regional markets serve as demand poles for the commodity because of the large presence of consumers.

The north, the center and the south of Benin have different seasonal patterns and this allows arbitrage between regions and grain movement between surplus and deficit areas over time. Indeed, the south and the center enjoy two rainy seasons alternated with two dry seasons, while the north only has one rainy season followed by a dry season. Maize is only produced during the rainy season since there is no adequate irrigation system to allow production during the dry season. However, large quantities of the maize produced during the rainy season may be dried during the dry season, and stored over several months or years. Wholesalers tend to store more than retailers because they have higher business capital which allows them to finance storage costs.[4]

Seven regional markets are considered in this article: Cotonou, Bohicon, Parakou, Azove, Glazoue, Ketou, and Nikki. These markets represent important poles through which large quantities of maize flow throughout the year. Cotonou, Azove and Ketou are located in the South, Bohicon and Glazoue in the center, while Parakou and Nikki are northern markets. All these markets receive significant quantities from the production area located around them. But large flows of maize also transit to or from these markets throughout the year. Depending on the time of the year, the trade flow between markets may be different (see Figure 1). In most cases, the trade flow between any two markets is bi-directional. The double arrows in figure 1 indicates the potential for bi-directional trade, which may take place at different times of the year, depending upon levels of relative abundance or shortage of the commodity across locations. The direction of trade differs between two main periods: July - February which is usually referred to as an abundance period, and March - June which is known as the dead season.[5] Cotonou, known as the principal urban market in the country, receives maize from all the other markets. Trade along the Parakou-Glazoue-Bohicon-Cotonou axis is favored because of the relatively good quality of the road. Traders from Ketou prefer to sell their commodity to Cotonou traders with whom they have tight cultural relationships. Despite the proximity to Bohicon's market, the traders from Ketou do not often trade with Bohicon

[2] During rainy seasons, roads are in poor conditions, making it difficult to transport maize from production areas to local or regional markets.

[3] Retailers may buy from wholesalers and sell back to consumers on regional markets.

[4] Storage requires some specific equipment such as bags, tanks and some chemical products to prevent the proliferation of insects in the maize.

[5] The dead season corresponds to the period where there are no farming activities. It is also referred to as dry season.

traders, mainly because of high transportation costs associated with the poor quality roads linking the two markets. During the abundance period, Azove market traders prefer to trade with Bohicon traders, but also with Cotonou and Parakou traders. Despite the long distance, Nikki and Bohicon are historical trading partners. Trade between these two markets is favored by the fact that several wholesalers have established some networks on both markets to facilitate transactions.

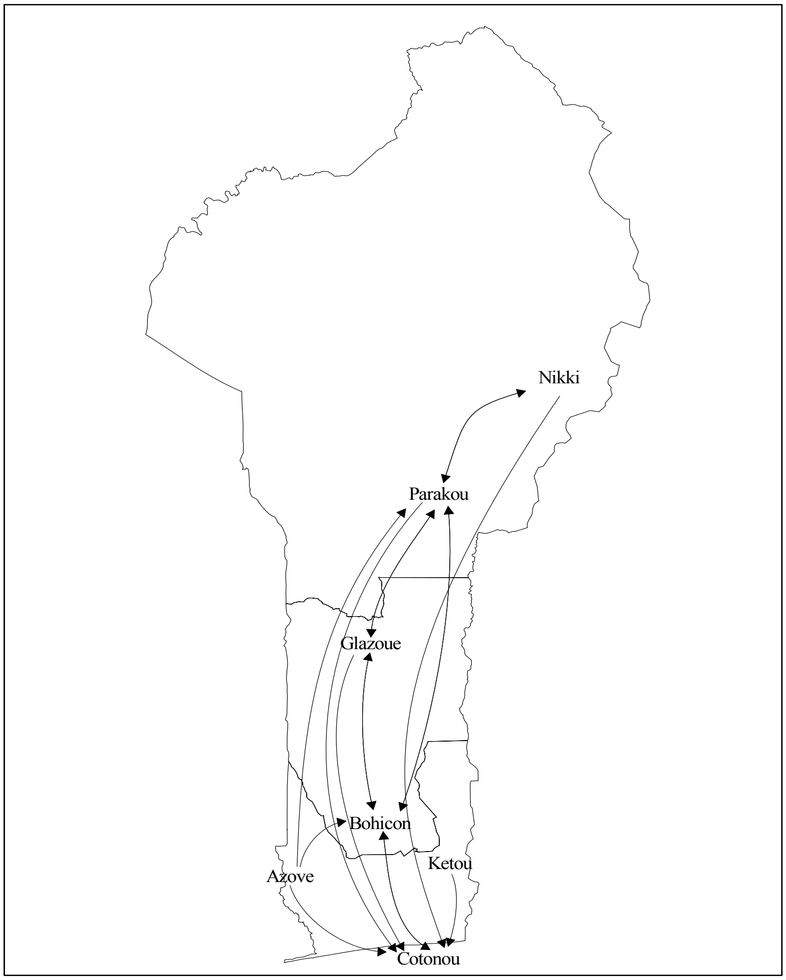

Figure 1. Maize Flows in Benin

All seven markets, except Cotonou, are governed by informal traders' associations and four of them (Ketou, Nikki, Glazoue, Parakou) impose important trade barriers on non-resident traders. These associations, composed of the traders themselves, control the maize supply from the surrounding production areas. Wholesalers belonging to these associations are the only ones allowed to collect maize from the production areas of their market. Non-resident traders are always obliged to comply with the rules and instructions of those associations. Also, the local farmers are not organized in association, and consequently must comply with the rules set by the wholesalers' association. This gives the wholesalers the power to influence prices at the farm gate and on local markets. These non-competitive practices represent trade barriers for non-resident traders since they cannot buy directly from production areas which are not in their own residential area. The trade barriers lengthen the marketing chain between consumers and farmers and add additional costs and inefficiencies to the marketing system.

MOTIVATION

Before 1990, the Benin government has tried to control and regulate the maize market system. Some of its interventionist policies have hampered the local and temporal development of a free market system (Lutz, 1995). The goal of the government intervention was to fight unfair and anti-competitive marketing practices of wholesalers' associations.

However, the wholesaler's associations were not removed by the liberalization process, initiated in 1990, and their own market regulations, which promote price distortions, persist in the current marketing system. Lutz (1994) observed that over the period of government regulation, Benin maize markets were integrated in the long run; however, price adjustment was sluggish in the short run. He argued that the sluggishness of price adjustments between markets could be attributed to strong trade barriers created and imposed by wholesaler associations' regulations.

Given the key role played by wholesalers' associations and their powerful entrenched influence on the marketing system, the government's liberalization policy focused on improvement and collaboration with – rather than removal of – the associations. To facilitate the access to information on trade opportunities was one of the priorities of the government. The MIS was thus initiated to fulfill that goal. The MIS functions consist of publishing a monthly bulletin on prices and markets conditions, posting information on each market place, and broadcasting price information on radio stations. Traders are also informed about market opportunities inside or outside the country and are provided organizational training and assistance. It was hypothesized that the availability of reliable market information for all the market agents would allow the market to perform more efficiently. Moreover, it was assumed that a free market system would perform more efficiently and enhance market integration compared with the government-regulated systems.

To reiterate, this article investigates the effectiveness of initiatives undertaken under the liberalization reforms to promote an efficient marketing system. More explicitly, the article examines whether markets have become better integrated following the implementation of the liberalization strategies.

METHOD

Cointegration analysis has frequently been used in the literature to test for market integration. This body of literature has typically assumed that if spatially separated commodity markets are found to be cointegrated, and hence linearly linked by a long-run equilibrium relationship, this is an indication that the markets are integrated through trade. Recent literature has focused on the influence of transaction costs, seasonality, and threshold effects on tests for integration: Balke and Fomby (1997), Balke and Wohar (1998), Lo and Zivo (2001), Baum et al. (2001), Baum and Karasulu (1998), Enders and Falk (1998), Hansen and Seo (2002), Ching-Chung et al. (2003), Goodwin and Piggot (2001). For example, the physical costs associated with transporting a commodity from one market to another may preclude trade taking place if the price differential between markets is too small to compensate potential arbitrage traders for these costs. In such a case, prices between markets could deviate and show no tendency to revert back to a long-run equilibrium unless price differences exceeded some transaction cost level. Threshold cointegration models capture this behavior by estimating the transaction cost or threshold level needed to adjust prices back to a long-run equilibrium. Thus threshold models assume market prices evolve independently when deviations from equilibrium are small, but assume market prices are cointegrated when the disequilibrium is substantial.

Although several studies have analyzed maize market integration in Benin, most of them have ignored the influence of transaction costs and threshold effects. As pointed out by Goodwin and Piggot (2001), ignoring transaction costs may affect test results and inferences about market integration. Even in the post reform period, transaction costs represent important features of the marketing system in Benin and, hence, have potentially a large influence on the degree of markets' integration. Following several years of the free market system, it is of great importance to assess the extent to which this has led to a higher degree of market integration. The present article is placed in this context and it analyzes the mechanism of price integration in Benin maize markets with an emphasis on transaction costs and threshold effects. Hansen and Seo's (2002) two-regime threshold cointegration approach is used to characterize the price integration between seven regional markets in Benin. Among the few studies which have addressed the concepts of transaction costs and threshold effects in Benin maize market is Lutz et al. (2006). This study used the traditional Johansen procedure incorporating impulse response analysis and a threshold cointegration type approach to compare the market integration under the pre and post liberalization periods. In this article we build upon Lutz et al. (2006) by employing Hansen and Seo's threshold-cointegration approach, which simultaneously estimates the threshold and cointegrating vector. Although in theory a two-step estimation approach is appropriate if the residuals from the cointegrating relationship follow a univariate self-exciting threshold autoregressive (SETAR) process, in practice such a procedure is subject to misspecification as the likelihood function on which the cointegration estimates are based depends on the threshold parameters (Rapsomanikis and Karfakis, 2007). In this sense our modeling approach is superior to previous research which has used a two-step estimation approach.

The price series are first tested for unit roots using the Augmented Dickey-Fuller (ADF) test. Both the Engle-Granger test and Johansen multivariate cointegration procedures are applied to formally test the long-run relationship between market pairs. For those markets which were found to be linearly cointegrated, we proceeded to test for threshold effects. The Hansen and Seo (2002) approach tests for two-regime threshold cointegration and it considers a vector error-correction model (VECM) with one cointegrating vector and threshold effect based on the error-correction term. The Hansen and Seo (2002) approach provides Maximum Likelihood Estimation (MLE) of the threshold for the complete bivariate model. The testing method focuses on the complete multivariate threshold model. To this end, first a joint grid search procedure is used to determine the threshold and the cointegrating vector. The second step consists in testing for the significance of a threshold effect. In other words, it is determined whether the dynamics of the long-run relationships among prices are linear or whether they exhibit threshold type nonlinearities. The null hypothesis to be tested is that there is no threshold, which means that the model reduces to a conventional linear VECM. For the complete bivariate specification between any two market prices, the SupLM[6] test is used to test for the presence of threshold effect in the case where the cointegrating coefficient is estimated and when it is set to unity.

Intuitively the two-regime TVECM allows for characterization of a trading environment in which trade between spatially separated markets only occurs when relative price differences exceed some threshold level. In the regime where relative price differences exceed the threshold level, which we will refer to as the a-typical regime, trade will promote market integration and induce price movements and responses between markets. In this sense, markets may be cointegrated within this a-typical regime. The typical regime occurs when relative price differences between markets are less than the threshold level. In this case there is no incentive to trade and price movements between markets and within the transaction cost band will be unrelated. In other words, the markets will not be cointegrated. It should be noted that, as in Balke and Fomby, the Hansen and Seo model bases the estimated threshold upon the error-correction term, which captures the long run equilibrium relationship. In this sense, market responses are conditioned upon deviations from long run equilibrium, which should implicitly capture the level of transaction costs associated with trade and arbitrage. In the results section of the article, we explore the validity of this assumption by comparing threshold estimates with actual observed physical transaction costs.

Following the two-regime threshold model outlined in Hansen and Seo (2002), let x_t be a two-dimensional vector of price series. If the price series are both integrated of order 1 and we assume that there is a long term relationship between the two price series with cointegrating vector β, the Vector Error Correction Model (VECM) of order $l+1$ can be written as follows:

$$\Delta x_t = A' X_{t-1}(\beta) + \mu_t \tag{1}$$

where

$$X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ . \\ . \\ \Delta x_{t-l} \end{pmatrix} \tag{2}$$

[6] Since the threshold parameter is not identified under the null hypothesis, following Hansen and Seo, inference is based upon a SupLM test. (See Andrews and Ploberger (1994) for motivation and justification of using a SupLM test.) .

In the above equation, $X_{t-1}(\beta)$ is $k \times 1$ and the matrix A is $k \times 2$ where $k = 2l + 2$. The model also assumes that the error term u_t is a vector Martingale Difference Sequence (MDS) with finite covariance matrix $\Sigma = E(u_t u_t')$. The term w_{t-1} represents the error correction term obtained from the estimated long term relationship between the two market price series.[7]

The parameters (β, A, Σ) are estimated following a maximum likelihood approach with the assumption that the errors u_t are independently and identically Gaussian. The representation of the VECM with a two-regime threshold is given as:

$$\Delta x_t = \begin{cases} A_1' \; X_{t-1} + u_t & if \quad w_{t-1} \leq \gamma \\ A_2' \; X_{t-1} + u_t & if \quad w_{t-1} > \gamma \end{cases} \tag{3}$$

where γ represents the threshold parameter. The model in equation (3) may also be written as

$$\Delta x_t = A_1' \; X_{t-1}(\beta) d_{1t}(\beta, \gamma) + A_2' \; X_{t-1}(\beta) d_{2t}(\beta, \gamma) + u_t \tag{4}$$

where

$$d_{1t}(\beta, \gamma) = 1 \quad (if \quad w_{t-1} \leq \gamma) \tag{5}$$

$$d_{2t}(\beta, \gamma) = 1 \quad (if \quad w_{t-1} > \gamma) \tag{6}$$

The matrices A_1 and A_2 will determine the dynamics in the first and second regime, repectively. Values of the error-correction term, in relation to the level of the threshold parameter γ, (in other words, whether w_{t-1} is above or below γ) allow all coefficients – except the cointegrating vector β – to switch between these two regimes.

In the Hansen and Seo (2002) model, threshold effects exist if $0 < P(w_{t-1} \leq \gamma) < 1$, otherwise the model reduces to a linear cointegration form. This constraint is imposed in model estimation by assuming $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$, where $\pi_0 > 0$ is a trimming parameter; π_0 is set equal to 0.05 in the empirical estimation. Setting π_0 equal to 0.05 ensures that indicator function represented by equations (5) and (6) contain enough sample variation for each choice of γ. The likelihood function of the model in equation (4) is given as:

---

[7] If x_t is a two-dimensional vector of price series such that $x_t = (x_{1t}, x_{2t})$, the error correction term is given by $w_{t-1} = x_{1t-1} - \beta x_{2t-1}$, where β is the cointegration vector.

(7) $$\ln(A_1, A_2, \Sigma, \beta, \gamma) = -\frac{n}{2}\ln|\Sigma| - \frac{1}{2}\sum_{t=1}^{n} u_t(A_1, A_2, \beta, \gamma)'\Sigma^{-1} u_t(A_1, A_2, \beta, \gamma)$$

where

(8) $$u_t(A_1, A_2, \beta, \gamma) = \Delta x_t - A_1' \ X_{t-1}(\beta) d_{1t}(\beta, \gamma) - A_2' \ X_{t-1}(\beta) d_{2t}(\beta, \gamma)$$

Hansen and Seo (2002) obtained the maximum likelihood estimates (MLE) of A_1, A_2, β, and γ by maximizing $\ln(A_1, A_2, \Sigma, \beta, \gamma)$. This is achieved by first holding (β, γ) fixed, and computing the constrained MLE for (A_1, A_2, Σ) using OLS regression.

(9) $$\hat{A}_1(\beta, \gamma) = \left(\sum_{t=1}^{n} X_{t-1}(\beta) X_{t-1}(\beta)' d_{1t}(\beta, \gamma)\right)^{-1} \left(\sum_{t=1}^{n} X_{t-1}(\beta) \Delta x_t' \ d_{1t}(\beta, \gamma)\right)$$

(10) $$\hat{A}_2(\beta, \gamma) = \left(\sum_{t=1}^{n} X_{t-1}(\beta) X_{t-1}(\beta)' d_{2t}(\beta, \gamma)\right)^{-1} \left(\sum_{t=1}^{n} X_{t-1}(\beta) \Delta x_t' \ d_{2t}(\beta, \gamma)\right)$$

(11) $$\hat{u}_t(\beta, \gamma) = u_t\left(\hat{A}_1(\beta, \gamma), \ \hat{A}_2(\beta, \gamma), \ \beta, \gamma\right)$$

and

$$\hat{\Sigma}(\beta, \gamma) = \frac{1}{n}\Sigma \hat{u}_t(\beta, \gamma) \hat{u}_t(\beta, \gamma)'$$

After A_1, A_2, and Σ have been estimated, the MLE of β and γ are obtained by minimizing $\ln\left|\hat{\Sigma}(\beta, \gamma)\right|$ subject to the constraint: $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$. Hansen and Seo (2002) used a grid search algorithm to obtain the MLE estimates of β and γ. The grid search procedure requires a region over which to search. To this end, two confidence intervals $[\gamma_L, \gamma_U]$ and $[\beta_L, \beta_U]$ are constructed for β and γ respectively.[8] The grid search over (β, γ) examines all pairs (β, γ) on the grids on $[\gamma_L, \gamma_U]$ and $[\beta_L, \beta_U]$ subject to the constraint $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$. In the empirical application the grid search procedure is carried out with 200 gridpoints. Once β and γ have been estimated, the presence of threshold cointegration is tested using the SupLM, where the null hypothesis of

[8] The notations *L* and *U* represent respectively lower and upper values.

linear cointegration is tested against the alternative of threshold cointegration. Empirical results presented in this article were estimated using a GAUSS software algorithm.[9]

DATA

The data used in the study are weekly maize price series over the period September 1998 to September 2001. These data were collected by ONASA (Office Nationale de Sécurité Alimentaire). The prices series are for seven spatially dispersed maize markets: Azove, Bohicon, Cotonou, Glazoue, Ketou, Nikki and Parakou. These price series are referred to as retail prices, and they represent prices paid by consumers, and they are expressed in CFA per kilogram.[10] All of the markets in the study are physical market places where sellers display their commodities. The sellers are wholesalers or retailers, rarely farmers. The buyers may be consumers, retailers or even wholesalers. Wholesalers are mainly involved in arbitrage: they move the commodities from one market to another depending on price opportunities. Buyers come to the market to buy directly from sellers. During the buying process, bargaining is allowed, but we would not consider these markets to be traditional auction type markets. Cotonou may be considered as the central market and receives maize from all of the other markets. Likewise, large quantities of maize may be transported from Cotonou to other markets. There is no terminal market per see and all markets may receive or deliver maize during different periods of the year.

Five of the markets (Azove, Bohicon, Cotonou, Ketou and Nikki) are 4 days-cycle markets while two of them (Glazoue, Parakou) are weekly markets.[11] In order to have a common cycle for all markets, we transform the price series of the 4-days cycles markets into weekly series. If one cycle falls in a week, then the price of that market day is taken as the price of the week. If two cycles fall in the same week then the average of the two cycles is taken as the price of that week.[12] The total number of observations per market is 162.

Physical transaction costs associated with trade were computed based on previous studies by Adegbidi et al., (2003), Pede (2001) and Lutz (1994), and are used as a metric to determine the extent to which our estimated threshold levels reflect costs observed in the market place. These transaction costs are composed of the transfer costs between markets, the gross margin of wholesalers and the gross margin of retailers.[13] The transfer costs represent all the costs involved in moving the commodity from one market to another. These costs are: taxes per bag of maize, transportation fees per bag of maize, transportation fees of the trader, cost of measurement per unit, cost of bag sewing, collection fees, costs of truck loading at the departure market, unloading costs at the destination market, costs of storage, and the costs of broker services.

[9] The GAUSS program used to implement the threshold model is provided by Bruce Hansen on his website at: http://www.ssc.wisc.edu/~bhansen/progs/progs_threshold.html

[10] CFA is the currency used in Benin. 1US dollar is approximately 440 CFA.

[11] A market day is an official day where a crowd of wholesalers, retailers, and consumers gather at the market place to exchange commodities. The market day is common knowledge to all market agents.

[12] In the dataset when the situation of two cycles in the same week happens, the prices usually remain constant or they are very close. This shows the sluggish change of prices in the short term.

[13] The computed transaction costs simply represent proxies of the real transaction costs. The real transaction costs between markets would include more than the costs mentioned. The other costs such as information costs, cost related to personal knowledge of markets, personal network, transaction skills, time, location, organization, institutional setting, and so forth, are difficult to estimate.

RESULTS

Table 1: Test of Stationarity for Price Series in Levels and First Difference.

	ADF test statistics	
Price series	Level	First difference
Azove	-2.73	-7.97**
Bohicon	-1.98	-8.72**
Cotonou	-1.11	-9.76**
Glazoue	-2.30	-10.90**
Ketou	-0.47	-7.28**
Nikki	-3.06	-9.41**
Parakou	-0.50	-8.05**

** Critical value at 5% is -3.45

ADF tests indicated that each of the price series – in levels – contain a unit root, while each of the series – in first differences – were found to be stationary (Table 1) . We concluded that the price series follow an I(1) process and proceeded to test for linear cointegration among each of the market pairings.[14]

Results presented in table 2 provide evidence for linear cointegration between several market pairings. Using the Engle-Granger test we found five market pairings to be cointegrated. The Johansen test results showed ten markets pairings to be cointegrated. All the linear cointegration relationships found by the Johansen test make intuitive sense according to empirical knowledge of market trade flows between these markets but with two exceptions: Ketou-Nikki and Ketou-Parakou. The Ketou market does not trade directly with either Nikki or Parakou due to the bad condition of the road from Ketou to these two markets. The routes from Ketou to these two markets require more transportation costs and as such, traders from the Ketou market prefer to trade with traders from the Cotonou market. Cotonou and Ketou markets trade intensively throughout the year. Therefore it was expected that Ketou and Cotonou markets should be cointegrated. However, neither Johansen nor Engle-Granger tests detected linear cointegration between these two markets. Lutz et al. (2006) also found that Ketou was not integrated with Cotonou. They argued that Ketou prices may be disconnected from other Benin maize markets because Ketou wholesalers actively trade with Nigerian markets as well.[15]

Moreover, based on the trade flows in the maize market, it was also expected that linear cointegration relationships would exist for three other market pairs: Azove-Cotonou, Bohicon-Parakou, Glazoue-Parakou. However, neither Johansen nor Engle-Granger tests detected linear cointegration for these markets pairs. The lack of linear cointegration for some of the above-mentioned market pairs may be explained by the presence of trade barriers on some of these markets or by the existence of imperfect market information between these markets. In such cases, although trade between markets may be observed, it may not occur in enough volume or frequency to affect prices. Thus in spite of trade, the market system

[14] Likelihood ratio test results, based upon an initial eight week lag structure, indicated a single lag was optimal for all of the bivariate VECM's.

[15] Due to its proximity with Nigerian borders, the Ketou market sometimes trades significant quantities of maize with Nigeria.

between these locations is not well integrated and performs poorly in terms of its role to provide price signals.

Table 2: Engle-Granger and Johansen Tests of Linear Cointegration

Markets pairings		Linear Cointegration Test	
		Engle-Granger	Johansen
Azove	Bohicon	cointegrated	cointegrated
Azove	Cotonou	not cointegrated	not cointegrated
Azove	Glazoue	cointegrated	cointegrated
Azove	Ketou	not cointegrated	not cointegrated
Azove	Nikki	not cointegrated	not cointegrated
Azove	Parakou	not cointegrated	cointegrated
Bohicon	Cotonou	not cointegrated	cointegrated
Bohicon	Glazoue	cointegrated	cointegrated
Bohicon	Ketou	not cointegrated	not cointegrated
Bohicon	Nikki	not cointegrated	cointegrated
Bohicon	Parakou	not cointegrated	not cointegrated
Cotonou	Glazoue	not cointegrated	cointegrated
Cotonou	Ketou	not cointegrated	not cointegrated
Cotonou	Nikki	not cointegrated	not cointegrated
Cotonou	Parakou	cointegrated	cointegrated
Glazoue	Ketou	not cointegrated	not cointegrated
Glazoue	Nikki	not cointegrated	not cointegrated
Glazoue	Parakou	not cointegrated	not cointegrated
Ketou	Nikki	not cointegrated	cointegrated
Ketou	Parakou	cointegrated	cointegrated
Nikki	Parakou	not cointegrated	not cointegrated

Table 3. Test for Threshold Cointegration (p-values).

Market pairings		Bivariate		Univariate	
		$\beta = 1$	β estimated	$\beta = 1$	β estimated
Azove	Bohicon	0.2000	0.014**	0.8330	0.7370
Azove	Glazoue	0.1900	0.1620	0.3450	0.6190
Azove	Parakou	0.1860	0.5380	0.4750	0.5980
Bohicon	Cotonou	0.2000	0.0880*	0.2680	0.2420
Bohicon	Glazoue	0.1930	0.0300**	0.1850	0.1320
Bohicon	Nikki	0.1750	0.1740	0.9570	0.8680
Cotonou	Glazoue	0.0530	0.0110**	0.0980	0.1340
Cotonou	Parakou	0.2620	0.0610*	0.2600	0.2840
Ketou	Parakou	0.9280	0.1250	0.4650	0.1570

** indicates significance at 5%

* indicates significance at 10%

For the market pairings in which we found linear cointegration, we proceeded to test for threshold cointegration. The null hypothesis is linear cointegration and the alternative hypothesis is non-linear cointegration or threshold cointegration. Table 3 shows results pertaining to threshold cointegration. The left half of the table – labeled Bivariate – presents *p*-values with respect to SupLM test results for threshold effects. For comparative purposes the right half of the table – labeled Univariate – presents *p*-values with respect to Hansen (1996) threshold autoregressive test results applied to the error-correction terms as in Balke and Fomby (1997). Both sets of results include the case where β is estimated and the case where β is set equal to unity. *P*-value results are shown for one lag, with respect to each of the bivariate TVECM's. The *p*-values were computed by a parametric bootstrap as in Hansen and Seo (2002) using 1000 simulation replications. The univariate models ($\beta = 1$ and β estimated), and the bivariate models $(\beta = 1)$ reject the presence of threshold cointegration at the 5% level between all market pairs. However, there is evidence of threshold cointegration, for five of the bivariate models (β estimated). Hansen and Seo similarly found stronger evidence of threshold cointegration using their SupLM test in comparison to the univariate threshold autoregressive test. They noted that given the restrictive nature of the univariate specification, the power of the univariate test is undoubtedly reduced in some settings.

For those market pairings where we found threshold effects, we also analyzed the threshold cointegration results by comparing the estimated threshold parameters to observed market transaction costs. Table 4 lists estimated threshold parameters along with observed transaction costs for the one lag bivariate models (β estimated). The sign on the threshold parameter provides some intuition as to the direction of trade flows between markets. For example, with respect to the Bohicon-Cotonou model, the negative threshold estimate of -40 and the cointegrating vector estimate, β, of 0.9, would suggest that a trade inducing regime would occur, with trade flowing from Bohicon market to Cotonou, when $Bohicon \; - 0.9 Cotonou \leq -40$, in other words when the price in Bohicon market is more than 40 CFA below the price in Cotonou market.

Table 4: Estimated Cointegrated Vector, Threshold and Actual Transaction Costs

Market pairings		Estimated Cointegrated Vector β	Estimated Threshold γ	Actual Transaction Costs
Azove	Bohicon	0.7	23.5	37.2
Bohicon	Cotonou	0.9	-40.0	40.6
Bohicon	Glazoue	0.8	11.4	42.0
Cotonou	Glazoue	1.2	2.1	47.3
Cotonou	Parakou	0.6	54.1	55.4

Several discussion points arise from the above results with regard to the estimated cointegration vector β and the estimated transaction costs compared with the actual transaction costs. With respect to the β estimates, which may be thought of as price transmission elasticity estimates, the results are mixed. The β estimates range from 0.6 to 1.2, and the higher the value of β, the more responsive the market is to price movements. The greater price response is obtained with Cotonou-Glazoue with a β estimate of 1.2. These two markets are highly related in term of trade flow, favored by the good condition of the roads between them. The same characteristics are observed for the other markets pairs with relatively high values of the cointegrating vector β . However, Cotonou-Parakou shows a relatively smaller cointegrating vector, indicating weaker price responsiveness. This may be explained by the large distance between the two markets.

A priori we would have expected threshold estimates to exceed observed transaction costs, because the observed transaction costs are likely to be under-estimates of actual transaction costs. However, in absolute value terms, the threshold estimates are actually lower than the observed transaction costs. It is also interesting to note that the estimated threshold levels and the observed transaction costs are close in absolute terms for two of the market pairs: Bohicon-Cotonou and Cotonou-Parakou.

Next, we report the bivariate model's short-run price dynamics between the 5 market pairings that exhibited threshold effects. Table 5 presents price responses with respect to error-correction term $w_{t-1}(\beta)$ parameter estimates. The error-correction terms, which represent the estimated cointegrating relationship (lagged one week), capture price responses to perturbations from long-run equilibrium between markets. Error-correction parameter estimates reported in column 3 illustrate price reactions to long-run disequilibria in the typical regime. Recall that the typical regime occurs when relative price differences between markets are less than threshold transaction costs. Thus, the typical regime represents the case where there is no arbitrage trading-mechanism to return prices to their long-run equilibrium level, and hence within this regime we would not expect prices to be cointegrated or to observe error-correction effects. In general our results are consistent with these assumptions; error-correction parameters are typically small in magnitude and insignificant at conventional significance levels. Only two exceptions are observed (Cotonou price response with respect to Bohicon-Cotonou market pairing, and Glazoue price response with respect to Bohicon-Glazoue market pairing).

In contrast, error-correction effects for the a-typical regime are in general large and significant with respect to at least one of the market prices in each of our market pairings. Again, these results are in line with our *apriori* expectations which assume that within this regime, market prices will adjust to large perturbations (in excess of threshold transaction costs) in long-run equilibrium. In addition, each of the significant error-correction induced price responses is intuitively appealing in terms of market integration theory. For example, if we consider the case of Bohicon and Cotonou – two likely trading partners – results show that when the price in Bohicon is relatively lower than the long-run equilibrium price differential between the markets, we observe a positive price reaction in the Bohicon market the following month. Note that in this case a large negative error-correction value (that exceeds threshold value) in combination with the negative parameter estimate (-0.27) induce a positive price reaction to adjust market prices towards their long run equilibrium relationship. Figure 2 illustrates periods when the error-correction value exceeds the threshold and transaction cost levels, which occurs 10% of the time (Table 5).

Thus, on balance we find strong supporting evidence for threshold effects, in the form of economically intuitive short-run price dynamics, for each of our five market pairings. It appears that threshold cointegration techniques are able to explain price behavior for at least some of Benin's important maize markets. Threshold transaction costs in Benin may take many different forms. For example, the organizational structure of some of the markets might in part account for threshold costs. The trade barriers represented by traders' association lengthen the marketing chain between consumers and farmers and introduce additional costs and inefficiencies to the marketing system. The lack of integration between markets in typical regimes may be explained by the fact that the full market opportunities are not exploited by traders due to the existence of barriers. The lack of empirical evidence of threshold effects for all of our market parings may at first seem puzzling. However, this may be attributed to the fact that threshold transaction costs are so high for some of these markets that we simply do not observe enough a-typical price observations to estimate threshold levels. For example, the strongest barrier is found on the Ketou market, where we found no evidence of threshold effects. In this market not only is entry regulated, but the buying price is also set by the wholesaler's body, and the non-resident traders are obliged to buy at the price set by the local traders association.

Table 5: Price Responses for Market Pairings

Market Pairings	Price Response	Typical Regime $w_{t-1}(\beta)$	Observations (percentage)	A-Typical Regime $w_{t-1}(\beta)$	Observations (percentage)
Azove	$\Delta Azove_t$	-0.1		-0.95**	
		(-0.07)	86	(-0.14)	14
Bohicon	$\Delta Bohicon_t$	0.13		-0.25	
		(-0.07)		(-0.16)	
Bohicon	$\Delta Bohicon_t$	-0.09		-0.27**	
		(-0.07)	90	(-0.12)	10
Cotonou	$\Delta Cotonou_t$	0.18**		-0.19	
		(-0.06)		(-0.11)	
Bohicon	$\Delta Bohicon_t$	-0.08		-0.94	
		(-0.05)	94	(-1.15)	6
Glazoue	$\Delta Glazoue_t$	0.24**		8.53**	
		(-0.07)		(-2.38)	
Cotonou	$\Delta Cotonou_t$	-0.07		-0.62**	
		(-0.05)	91	(-0.09)	9
Glazoue	$\Delta Glazoue_t$	0.02		5.35**	
		(-0.06)		(-0.18)	
Cotonou	$\Delta Cotonou_t$	-0.07		-0.39	
		(-0.04)	94	(-0.63)	6
Parakou	$\Delta Parakou_t$	0.03		1.42**	
		(-0.02)		(-0.63)	

Eicker-White standard errors are reported in parentheses.
** indicate significant at the 0.05 level.

Although the Benin government has attempted to shift towards a free market environment, the organizational structure imposed by the traders' associations still represents a remaining barrier, which is at odds with the government's free trade objectives. Therefore it would not be an exaggeration to say that the presence of these informal traders' associations have hampered the development of a free market trade environment in the maize industry.

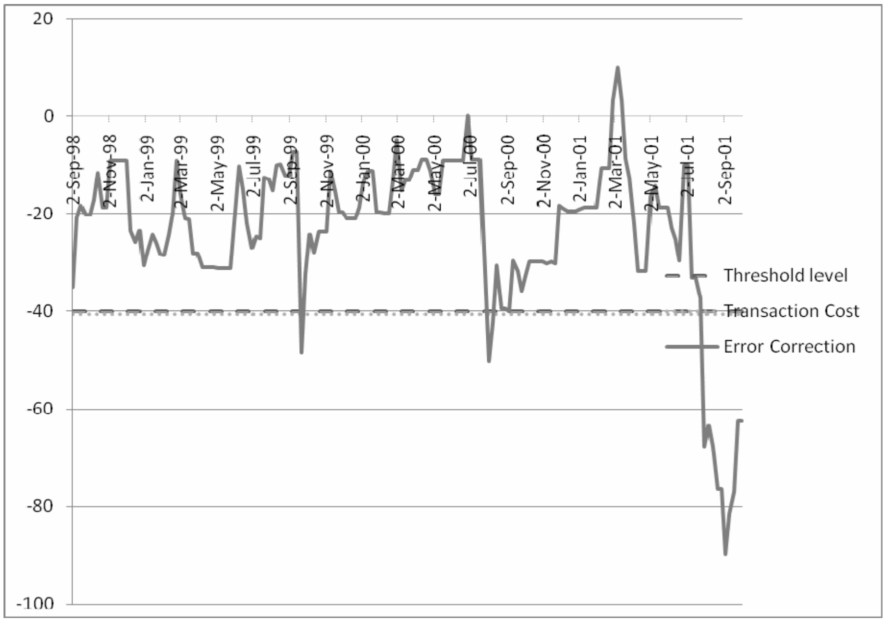

Figure 2. Error Correction Value in terms of CFA per kilogram for Bohicon and Cotonou Markets

The determination of price is heavily influenced by the trader's associations rather than by a true auction type market that we normally associate with free trade. This market environment is consistent with our empirical results, and we may conclude that our threshold model, at least to some extent, is able to capture these actual trade barriers.

The results presented in this article pertain to the period studied: 1998-2001. Therefore, our conclusions cannot be generalized to more recent times. However, the maize market environment has not basically changed in terms of conducts of traders since 2001. The marketing system has been rigidly established for several years, and the various trades practices seem to be commonly accepted among traders. Therefore, as our threshold results indicated, policies aiming at reducing transaction costs should rather be considered by the Benin government.

CONCLUSION

The present study applies the two-regime threshold cointegration model developed by Hansen and Seo (2002) to analyze integration in Benin maize markets over the period 1998-2001. We found strong evidence of threshold effects for five of our market pairings. In a similar vein to the threshold model, we did find some evidence of long run market integration with respect to the linear cointegrating model. This leads us to conclude that there is evidence of long run integration over our study period, but short run inefficiencies prevail. In the absence of very large price differentials, price adjustments necessary to return markets to their long-run equilibrium levels fail to materialize.

In contrast to our results, Lutz et al. (2006) find no evidence of threshold effects, although they do find Cotonou, Bohicon, Parakou, Azove, Glazoue and Nikki to be linearly cointegrated as a system. Consistent with our results, Lutz et al. (2006) report slow price adjustments to discrepancies from the long run for all markets, even in the post-reform 1998-2001 period. Thus, we agree with Lutz et al. (2006) that price adjustments between markets over the 1998-2001 period were sluggish. Our threshold results clearly support this conclusion, as they empirically demonstrate that markets will only respond quickly to large price discrepancies – exceeding threshold levels. Given that our estimated threshold levels do a reasonably good job of explaining observed transaction costs, future policies designed to lower transactions costs could be effective at further promoting market integration. Although the MIS has played an important role in enhancing price discovery, we would argue that further reform targeted at removing wholesaler association trade barriers is a necessary step to better integrate Benin maize markets.

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WOULD A FREE TRADE AGREEMENT BETWEEN BOLIVIA AND THE UNITED STATES PROVE BENEFICIAL TO BOLIVIAN HOUSEHOLDS?

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ABSTRACT

The world has witnessed an unparalleled increase in trade liberalization over the last few decades. These have been accompanied by increasing concerns over economic growth and distributional impacts emerging from trade agreements. An applied literature has emerged to address ex-ante effects at both macroeconomic and household levels. This article contributes to this literature by analyzing the case of Bolivia, which is about to initiate negotiations of a trade liberalization agreement with the US. We combine a computable general equilibrium model and a micro simulation approach to provide insights into whether the Bolivian economy and its households would win or lose from trade liberalization. The article indicates that Bolivia's efforts to reach a trade agreement with the US would pay off. However, an absolute trade liberalization scheme would not be the best option for the Bolivian poor. Sector specific measures in the form of protection to sensitive commodities would ensure that expected benefits would be more evenly distributed across most Bolivian households. Negative impacts from the elimination of US trade preferences to Bolivia and failure to sign a trade agreement with the US, suggest that a strong protectionist trade policy and limited trade relations have to be avoided if economic growth and household wellbeing are to be improved.

JEL codes: F13, F14, F17
Key words: Trade policy, macro-micro simulation, livelihoods, Bolivia

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INTRODUCTION

International trade has grown substantially in the last few decades. Supporters of free trade assert that this growth has provided important opportunities for countries to benefit from new market niches, improve efficiency, promote innovation in technology and management, encourage technology transfer, and enhance productivity growth, which in turn has contributed to the economic wellbeing of countries.

Others perceive that international free trade has not contributed to economic development and, in some cases, has worsened inequality, unemployment and poverty particularly in rural areas of developing countries (Berthelot, 2002). The perception of some developing countries is that they are left out of the benefits emerging from increased and freer international trade (Thomas, 2003). For example, as stated in the 2001 *Zanzibar Declaration*, trade ministers of Least Developed Countries (LDCs) are concerned at the marginalization of LDCs in the multilateral trading system as manifested in their insignificant share (0.4%) of world trade (WTO, 2001).

Bolivia stands on the threshold of negotiating an important trade agreement. Bolivia and the United States are expected to initiate trade talks towards a trade liberalization agreement in late 2008. This agreement might provide many potential gains, but also stirs concern among critics of free trade. A free trade agreement (FTA) with the United States, a country with significantly higher export capacity compared to Bolivia, is an issue of concern to Bolivian policy makers, the production sector, and civil society in general because of the asymmetries between these two countries. The US is Bolivia's most important trading partner and, thus, the stakes are high. The Bolivian National Institute of Statistics (BNIS, 2005) has estimated that about 60% of the Bolivian population is poor and the agreement could also have significant implications for poverty in Bolivia.

Yet, the sparse literature on trade agreements between these two countries indicates that no specific research has been carried out to estimate the economic implications that such a trade agreement would exert over the Bolivian economy and the economic wellbeing of its households. This article aims to fill this gap in knowledge. It does so by analyzing the multi-sectoral effects of trade liberalization using a computable general equilibrium model and computing corresponding price index changes at the household level.

BACKGROUND

Historically the Bolivian economy has relied on exports of natural resources, being one of the world's top five producers and exporters of tin and with the second-largest reserves of natural gas in South America. The agro-industrial sector, especially soybean production and exports, has also had an important impact on the Bolivian economy, becoming the second most important sector after mineral and natural gas extraction. Yet Bolivia is one of South America's poorest countries, with regional disparities in wealth distribution.

Bolivia had an estimated GDP of USD 26 billion in 2004, with a growth rate of 3.6% during the last five years. Bolivian exports and imports were USD 3.1 billion and USD 2.3 billion in 2006, respectively. Bolivian tariffs are uniformly set at 10%, with capital equipment imports charged at 5%. For ten years between 1994 and 2003 the Bolivian trade balance experienced deficits, reaching its peak in 1998 with a trade deficit of USD 1.1 billion. This deficit has only been reversed in the last few years (2004 to 2006) due to the higher exports of natural gas to Brazil and Argentina.

In general, Bolivia has historically had few trading partners, geographically located in the Americas. From 1994 to 2006 five countries (United States, Brazil, Argentina, Venezuela and Colombia) represented between 33% and 71% of total Bolivian exports, with the US historically being the most important trade partner.

The US has been a critical partner for the Bolivian economy, not only in terms of exchange in manufactures and food donations, but also in terms of preferential trade treatment. Under the 2002 Andean Trade Promotion and Drug Eradication Act (ATPDEA), the US has provided preferential duty-free treatment to Bolivia, Colombia, Ecuador and Peru on eligible articles exported to the United States. Relevant articles for Bolivia included textiles and apparel, which entered the US duty free and free of quantity limitations. In 2005, Bolivia exported to the US about 54% of its total exports under the ATPDEA.

The US long-term vision has been to operate the ATPDEA as a bridge to a FTA, which would imply that trade preferences the US has given to Bolivia through the ATPDEA will be superseded by a more comprehensive FTA. This FTA would provide permanent duty-free status to a wider range of commodities and would mean a ‘two-way avenue’ trade relationship, where both trading partners would reduce and eliminate most import tariffs.

However, recent empirical literature (e.g. Soludo et al. 2004; Berthelot, 2002) referring to new FTAs completed by developed (including the USA) and developing countries reveals concerns on the ability of FTAs to increase welfare of the poor. Yet, the debate is currently leaning to economists advocating for more integration and less trade restrictions, though critics doubt on the capacity of ordinary people to reap benefits from FTAs. The economic effects emerging from a prospective trade agreement between Bolivia and the US is a subject that has received almost no attention in terms of research efforts. Just a handful of empirical studies with slight references to trade agreements have been found, which are grouped here into two broad categories as follows: one studying macroeconomic effects from domestic policies and structural reforms (Thiele and Wiebelt, 2003; Jimenez et al. 2005; Klasen, 2005), and another focused on sectoral effects emerging from exchange rate shocks (Barja et al. 2004; Jemio and Wiebelt, 2003).

The focus of these studies varies across papers, covering the effects of structural reforms and external shocks over the Bolivian economy, including poverty issues at the macro and micro-economic levels. However, no explicit study estimating the economic effects emerging from an FTA between Bolivia and the US on Bolivian households has been found. In this context, this article is the first empirical reference for Bolivia in terms of an applied macro-micro simulation technique for the estimation of changes in economic wellbeing from prospective trade reforms between Bolivia and the United States.

METHODOLOGY

Macro-micro simulation approaches consist of Computable General Equilibrium (CGE) models that simulate economic shocks (e.g. trade reforms) that produce changes in domestic macro-variables (e.g., commodity prices, returns to factors of production, GDP, imports and exports and terms of trade), coupled with micro-simulation approaches that evaluate the effects of such macro-variable changes at the household level. In general terms, all macro-micro simulation approaches aim to answer the key question of how trade reforms affect the wellbeing of different household groups. Elements or variables affecting the wellbeing of households can be very diverse and go beyond economic considerations, as trade reforms also affect the social, cultural and political aspects of households. Referring strictly to economic considerations, macro-micro simulation approaches have been designed to study certain key variables that directly affect the livelihoods of households, which are grouped here into five categories as follows:

1. Domestic price and sources of income: the domestic commodity price is a very important variable to understand how trade reforms affect households. Domestic prices alter the value of the consumption bundle, affecting households' expenditures. On the supply side, trade reforms affect the prices that producers get for their products, affecting their livelihoods. In this case, micro-simulation approaches have been formulated to capture the way in which price changes influence the consumption basket of households. 'Sources of income' refers to income emerging from factors of production. These are skilled and unskilled labor, capital, land, transfers, etc. Trade reforms may affect returns to factors of production and, thus, affect the financial resources of households. To study these sources, micro-simulation approaches have concentrated on the analysis of employment, in particular the remuneration of unskilled labor, as this is the most plentiful resource from poor households (Ferreira Filho and Horridge, 2005).
2. Transmission of world prices: approaches have been developed to consider the extent to which local prices vary relative to international prices. In this case, CGE models generate changes in prices which are applied to household databases considering that there might be differential impacts by geographical areas depending on their market integration level. For example, in Mexico price transmission has been estimated to be high for areas with a high level of market integration, and low for areas isolated from markets (Nicita, 2005). Micro-simulation approaches have been formulated to reflect the extent to which changes in international prices are transmitted to local prices and their corresponding effects on household expenditure and income sources.
3. Labor markets and factor productivity: trade reforms might also affect the productivity of factors of production. In this case, macro-micro simulation approaches have been developed to study how trade reforms influence the movement of workers between sectors. Bussolo et al. (2005), for example, have studied how trade reforms affect the movement of workers from a relatively low-wage agricultural sector to higher wage non-farm jobs. In this kind of micro-simulation model, the analysis of agricultural labor productivity is of primary interest.
4. Tariff revenues: a recent IMF (2005) study points out that researchers have ignore the problem of the loss in government revenues when trade reforms take place. To overcome this problem, macro-micro simulation approaches have been designed to estimate the amount of tariff revenue losses (if any), the mechanisms to replace such tariffs, and the impacts that such replacement might have on household welfare. For example, Emini et al. (2005) used a micro-simulation model to estimate welfare impacts of different tax options (value added tax, direct taxation) to replace the loss in tariff revenue emerging from trade reforms.

5. Subsistence consumption (own agricultural production used for family consumption only): In least developed countries an important segment of the consumption bundle usually comes from auto-consumption. However, trade reforms may have no impact on such consumption. For such cases, approaches have been designed to assess the share of the consumption bundle which is not sensitive to price changes (Arndt, 2005).

A cross-cutting issue in all these categories is the so called 'policy baseline' setting. This refers to updating tariff information (or leading-up trade reforms) before examining the actual trade reform that it is intended to analyze. This policy baseline setting is needed when a major trade reform takes place in the country or region of interest. Given that Bolivia has experienced important trade-policy reforms in the last 20 years, we updated the policy-baseline (explained below) before the actual trade policy scenarios were conducted.

As described above, the macro-micro approach generally consists of using a CGE model to simulate policy shocks whose results are used by a micro-simulation model that, in combination with a household database, allows analysis of the effects of such policies at household-group level. For social and economic policy analysis this technique has the advantage of producing results that can be evaluated at the household level (Cockburn, 2001). In this article, we follow the lead of Ianchovichina et al. (2002) and use the GTAP model (Hertel, 1997) as the macro-simulation model, while the micro-simulation approach uses Laspeyres price indices for income and expenditures.

The GTAP model is a standard, static, multi-region, multi-sector general equilibrium model which includes explicitly treatment of international trade and transport margins, global savings and investment, and price and income responsiveness across countries. It assumes perfect competition, constant returns to scale, and an Armington specification for bilateral trade flows that differentiates trade by origin. It also assumes a fixed factor endowment and full factor use.

In this article we used the GTAP database, version 6.2, which represents a snapshot of the world economy in the year 2001. The results of this model for all variables are expressed as relative changes from the original GTAP database. That is, scenario results are percentage changes from the base case scenario. The macro-micro approach has been applied in three stages (figure 1):

The first stage is to set a pre-simulation (or pre-liberalization) scenario where, based on the household database, values of the consumption basket and income levels are estimated for each household category. The second stage is the simulation of trade liberalization scenarios using the GTAP model. The results of such simulations are then analyzed against key macroeconomic indicators of the Bolivian economy. The third and final stage is to use the results from the general equilibrium model (percentage changes in prices of commodities and sources of income), to estimate money metric estimations of changes in households' spending and revenues through the combined use of Laspeyres price indices for income and expenditures. Then, we compared both the pre- and post-liberalization scenarios and analyzed the impacts of trade reforms on households' economic wellbeing.

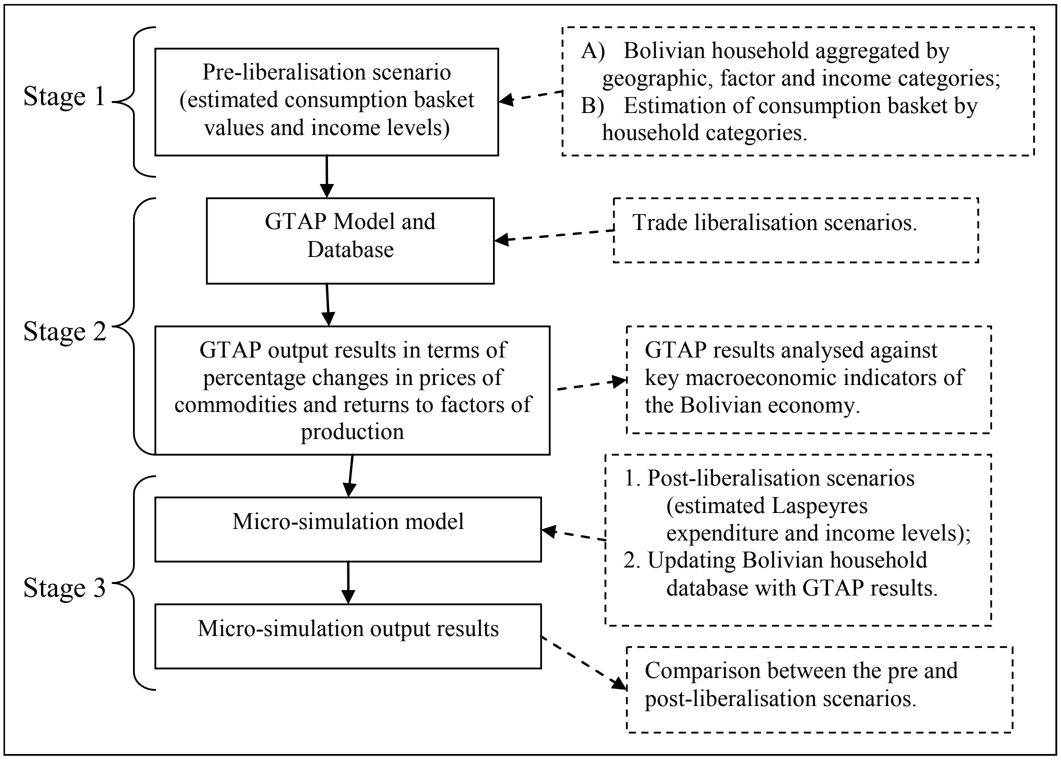

Figure 1. Macro-micro simulation stages

MODIFICATIONS TO THE GTAP DATABASE

We modified the GTAP model in two main areas: 1) Inclusion of the 2004 Bolivian input-output matrix into GTAP, and 2) updated tariff information contained in the GTAP database. These two modifications are explained in the following paragraphs.

Updating the Bolivian Input-Output Matrix

The GTAP global database Version 6.0, released in 2005, corresponds to the global economy in 2001, capturing economic activity in 57 different industries of 87 regions and countries worldwide. The global GTAP database works with inter-industry flows, which are based on national Input-Output (I-O) tables. This database is constructed with contributions from an international network of institutions and individuals. Since the creation of the first version of the GTAP global database in 1993, improved versions have included more regions/countries and sectors. However, Bolivia was not included in any of these previous versions.

Bolivia was included in the GTAP database for the first time by Ludena and Wong (2005), using data from the year 2000. This Bolivian I-O table was incorporated into the GTAP global database interim release 6.1. An updated Bolivian I-O matrix was transformed into a GTAP format through a collaborative effort between Purdue University and the University of Reading (Ludena and Telleria, 2007). This matrix used data for the year 2004 and was incorporated into the GTAP global database interim release 6.2 (May 2006).

Updating Tariff Information in the GTAP Database

The GTAP database version 6.2 does not include some trade agreements that Bolivia signed before 2001, year to which the GTAP database corresponds. Therefore, tariff updating was done by defining 'sensitive'[5] products for each country included in the regional aggregation (described below) and with tariff information obtained from pre-2001 FTAs listed in Table 1:

Table 1. List of Pre-2001 and Post-2001 Free Trade Agreements

Pre-2001 FTAs		Post-2001 FTAs (2002-2006)	
Agreement	**Year**	**Agreement**	**Year**
Argentina – Bolivia	1996	Bolivia – US (ATPDEA)	2002
Argentina – Chile	1996	Chile – EU	2003
Bolivia – Chile	1993	Chile – US	2004
Bolivia – Brazil	1996	Colombia – US	2006
Brazil – Chile	1996	Colombia – US (ATPDEA)	2002
Chile – Colombia	1993	Ecuador – US (ATPDEA)	2002
Chile – Ecuador	1994	Peru – US	2005
Chile – Peru	1998	Peru – US (ATPDEA)	2002
Chile – Venezuela	1993		

Source: Durán et al. (2007).

Since 2001, the economic environment (i.e., import tariffs from bilateral and regional trade agreements) has also changed and the economic world as presented in the 2001 GTAP database is no longer relevant. Therefore, we updated the GTAP database to include trade agreements signed between Latin American countries, which were relevant for Bolivia. For this update, we used the information on trade agreements signed between 2001 and 2006 (Table 1). Such updating set 2006 as a new baseline year, upon which the intended trade agreement simulations between Bolivia and the US were conducted.

SECTORAL AND REGIONAL AGGREGATION

The 96 regions (or countries) and 57 sectors (commodity groups), available in the GTAP database version 6.2, were aggregated into 11 regions and 29 sectors. The regional aggregation criterion consisted of choosing countries that are important trade partners for Bolivia (Table 2). That is, the United States, South American countries and the European Union represented between 77 and 97% of total Bolivian exports to the world between 1994 and 2006.

[5] Sensitive products are less competitive products in international markets, and important for both domestic food security and employment generation.

Table 2. Sectoral and Country Aggregation of the GTAP Database, Version 6.2

Sector	Description	Country	Description
Agriculture		1. Bolivia	Bolivia
1. Rice	Paddy rice	2. United States	US
2. Wheat	Wheat	3. Argentina	Argentina
3. Cereals	Corn, barley, other cereals	4. Venezuela	Venezuela
4. VegFruitNuts	Vegetables, fruit, nuts	5. Colombia	Colombia
5. OilSeeds	Oil seeds	6. Brazil	Brazil
6. OtherAgric	Sugar crops, plant-based fibers	7. Peru	Peru
7. RawMilk	Raw milk	8. Chile	Chile
8. Animal	Live cattle, sheep, pigs, wool	9. Ecuador	Ecuador
9. Fishing	Fishing	10. EU25	EU (pre-2007)
Mining		11. ROW	Rest of the World
10. Gas	Gas		
11. Energy	Coal, oil		
12. Mining	Minerals nec		
Manufactures Intensive in Natural Resources			
13. Meat	Meat and meat products		
14. VegOilsFats	Vegetable oils and fats		
15. DairyProduct	Dairy products		
16. FoodProducts	Processed food, beverages, etc.		
17. Sugar	Sugar		
Manufactures Intensive in Labor			
18. Textiles	Textiles		
19. Apparel	Wearing apparel		
20. LeatherProdu	Leather products		
21. WoodProducts	Wood products		
22. OthLightManu	Paper products		
Manufactures Intensive in Capital			
23. PetroleuCoal	Petroleum, coal products		
24. ChemRubPlast	Chemical, rubber, plastic prod		
25. MetalsNec	Ferrous metals, Metals nec		
26. MetalProduct	Metal products		
27. MotorVehicle	Motor vehicles, transport equip.		
28. MachinEquipm	Electronic and machinery equip.		
Services			
29. Services	Electricity, gas dist., water, construction, trade, transport, communications, financial and business services, public admin.		

Note: nec = Not elsewhere classified.

The 57 GTAP sectors were aggregated into 29 sectors (Table 2), grouped into six categories that use similar production factors. The reason for this grouping is that trade liberalization not only affects trade of commodities, but also the productive structure of the whole economy. Grouping sectors according to the similarity in the use of production factors facilitates the analysis of results.

TRADE POLICY SCENARIOS

Recent US trade agreements with Latin American countries (e.g., Central America and Dominican Republic, Peru, Colombia, and Panama) suggest that the United States has provided particular protection to some commodity groups considered as 'sensitive'. These have been beef, sugar and dairy commodity groups, whose tariffs in Peru and Colombia's FTAs will only be dismantled within 10–15 years after the agreements are implemented. In a prospective FTA between Bolivia and the United States, we assume that protection for these commodities will be maintained as in other FTAs. For Bolivia, sensitive commodity groups include rice, wheat, oil seeds, dairy products, textiles and leather products, to which Bolivia provides special protection when negotiating trade agreements. Three trade scenarios were defined as follows:

1. Scenario 1 − FTA (Bolivia–US full liberalization): in this scenario all Bolivian tradable products enter duty-free into the United States, and vice-versa. About 60% of Bolivian exports to that country already enter duty free under the ATPDEA. Therefore, this FTA considers an elimination of US tariffs for the remaining 40% of Bolivian commodities. In this case, we assumed that Bolivia removed tariffs on 100% of US commodities.
2. Scenario 2 − Restricted FTA (with 'sensitive products'): in this scenario, sensitive products are excluded from the trade liberalization treaty. Thus, it was assumed that the United States removes tariffs on about 30% of Bolivian commodities, while Bolivia would remove tariffs on about 75% of US commodities.
3. Scenario 3 − No ATPDEA (end of the ATPDEA): this scenario assumes that the US does not extend the ATPDEA beyond December 2008 (the date which the ATPDEA officially ends). Therefore, in this scenario it is simulated that the US increases tariffs to 60% of Bolivian products that previously benefited from the ATPDEA to levels of preferred country. Bolivia in this case does not change import tariffs to US products. This scenario implies that the FTA does not materialize, either because the trade negotiations fail, or due to lack of political will of the Bolivian and/or US government to convey a trade agreement.

Each scenario represents a clear trade paradigm. That is, while the first represents complete free trade, the second reflects free trade but coupled with concerns over sensitive commodities, and the third scenario reflects a paradigm of protectionism or lack of political will to reach a trade agreement.

MICRO-SIMULATION APPROACH

We follow Ianchovichina et al.'s (2002) micro-simulation approach to evaluate changes in wellbeing at the household level. This simple approach calculates the upper bound of household expenditure change caused by price changes predicted by a general equilibrium model, using Laspeyeres' index, defined as,

(1)
$$P_L = \frac{\sum_i p_i^1 q_i^0}{\sum_i p_i^0 q_i^0} \text{ x } 100$$

where P_L is the change in price level, p_i and q_i stand for the price and quantity of commodity *i*. Both prices and quantities are indexed by time, where *0* denotes the base period, and *1* refers to the post simulation period. This price index is normalized to a value of 100 in the base year, to indicate the percentage level of the price index in period *1* relative to the base year. The Laspeyres index overstates the increase in expenditure, as it does not account for substitution in consumption when prices change (zero elasticity of substitution). Thus, as pointed out by Ianchovichina et al. the Laspeyres index provides an upper bound measurement of the increase in expenditure, defining a worst case scenario.

To measure changes in economic wellbeing, Ianchovichina et al. use GTAP's private utility equation. The term 'private utility' is specifically used in this article to denote the difference between the Laspeyres index for income and the Laspeyres index for expenditures,

(2)
$$up(r) = \frac{yp(r) - \sum_{i \in TRAD} [CONSHR(i,r) \text{ x } pp(i,r)]}{\sum_{i \in TRAD} [CONSHR(i,r) \text{ x } INCPAR(i,r)]}$$

where *up(r)* represents the percentage change in private utility in region *r*; *yp(r)* is the percentage change in private household income in region *r*; *CONSHR(i,r)* is the share of *i* in total consumption in region *r*; *pp(i,r)* is the percentage change in the demand price of commodity *i* in region *r*; *INCPAR(i,r)* is the income expansion parameter (elasticity) of commodity *i* in region *r*. If preferences are homothetic (i.e., a change in budget will allow for proportional changes in the demand of commodities) the *INCPAR(i,r)* equals 1 for all commodities, and therefore Equation 2 collapses into the difference between a Laspeyres price index for income an a Laspeyres price index for expenditures,

(3)
$$up(r) = yp(r) - \sum_{i \in TRAD} [CONSHR(i,r) \text{ x } pp(i,r)]$$

Equation (3) is the difference between the change in household income and the product of a consumption share times the percentage change in prices. In other words, this equation is a measure of economic wellbeing change, given that it computes economic change as the difference between changes in income and expenditures. In turn, household income is defined as the sum of the share in household's endowments (skilled labor, unskilled labor, capital, land and natural resources), times the percentage change in price of these endowments, $ps(r)$,

(4)
$$yp(r) = \sum_{i \in Endowment} INCOMESHR(i,r) \text{ x } ps(r)$$

The Laspeyres price index provides a fixed-weight approximation of economic private utility emerging from a change in income sources and a change in cost of living. Given the large size of the 2002 Bolivian household database (5,746 household questionnaires) used in this research, three approaches were used to group the data, allowing analyzing the micro-simulation results from several perspectives, including:

a) Earnings specialization: households were stratified according to their reliance on sector-specific factors of production (Hertel et al. 2004).

Table 3. Sector-specific Factors of Production in Bolivian Household Survey

Production factor	Number of questionnaires	%
Agriculture	2,086	39
Non-agricultural	614	11
Capital	1,303	24
Natural resources	764	14
Diversified	623	12
Total	5,390	100

Note: 356 questionnaires were eliminated as no information on household head's main economic activity was available.

Source: Own classification based on the 2002 Bolivian household survey.

b) Income levels: households were grouped into six sextiles of income categories, ranking them from the poorest to the wealthiest groups.

Table 4. Income Groups in Bolivian Household Survey

Income group	Income Range(Bs/month)	Number of questionnaires	Share (%)
I	<= 390	956	16.7
II	390 - 695	950	16.6
III	695 – 1,033	953	16.7
IV	1,033 – 1,538	953	16.7
V	1,538 – 2,547	953	16.7
VI	2,547+	952	16.7
Total		5,717	100

Note: Due to missing data, 29 questionnaires were excluded.

Source: Own classification based on the 2002 Bolivian household survey.

c) Geographical area: households were classified according to geographical regions, departments and rural/urban condition.

Source: Own classification based on the 2002 Bolivian household survey. Household head income was used instead of total household income considering that the household database contains quite incomplete information on income of other household members, preventing the accurate estimation of total household income. In addition, contributions of other household members generally represent a small share of the total household income and, in most cases, such contributions come from occasional work. This also avoids further discussions of the validity of other household income equivalencies, such as the well known 'adult equivalency.[6]

Table 5. Geographical Grouping of Households in Bolivia

Region	Department	Rural	Urban	Total	%
Altiplano	1. La Paz	430	789	1,219	21
	2. Oruro	239	297	536	9
	3. Potosí	350	282	632	11
	Sub-total	1,019	1,368	2,387	42
Valley	4. Cochabamba	373	538	911	16
	5. Chuquisaca	262	215	477	8
	6. Tarija	199	277	476	8
	Sub-total	834	1,030	1,864	32
Plain	7. Beni	147	265	412	7
	8. Pando	95	48	143	3
	9. Santa Cruz	320	620	940	16
	Sub-total	562	933	1,495	26
Total		2,415	3,331	5,746	100

Note: Bolivia is geographically classified into 9 departments. A department is equivalent to what would be a county in England, or a state in the US.

MACRO RESULTS

The results discussion focuses on the most important variables relevant to evaluate which trade reform is the most beneficial for Bolivia from both macro and micro simulation viewpoints. We begin our discussion with the macroeconomic results and later focus on the results at the household level.

Aggregate Welfare Outcomes

The complete liberalization scenario (FTA) would represent for Bolivia a net positive welfare effect of USD 7.2 million per year (Table 6). In the second scenario there is also a positive welfare effect indicating that the Bolivian society would be indifferent to implementing a restricted FTA and a transfer of USD 5.6 million per annum. The model results set the last scenario as the worst case for Bolivia, indicating that the end of unilateral trade preferences (no ATPDEA) would result in a net loss of USD 4.1 million per year. For the United States, the trade liberalization scenarios represent a net positive welfare effect of USD 19.8 and 19.5 million per year respectively, with the third scenario representing a negligible net welfare gain of USD 0.8 million per annum.

[6] Szekely et al. (2000) have found out that estimations of total household income under 'adult equivalency' methods can be very sensitive to assumptions about the existence of economies of scale in consumption, approaches for treating missing and zero earnings, and different adjustments to deal with income misreporting.

Table 6. Aggregated Welfare Changes for Bolivia and US

Welfare indicator	Bolivia Scenario 1 FTA	Bolivia Scenario 2 Restricted FTA	Bolivia Scenario 3 No ATPDEA	US Scenario 1 FTA	US Scenario 2 Restricted FTA	US Scenario 3 No ATPDEA
Change in EV (million USD)	7.2	5.6	-4.1	19.8	19.5	0.8
Change in GDP (%)	0.572	0.434	-0.317	0.001	0.001	0.000

EV = Equivalent variation is a welfare measure (in monetary terms) of the simulated policy scenario.

The Bolivian GDP would increase annually by 0.57% and 0.43% under Scenarios 1 and 2 respectively, and decrease by 0.32% per year under Scenario 3. US GDP would increase by negligible amounts (0.001% per annum in the first two scenarios, and no increase in the third scenario). This result was expected given that Bolivia is a minor trade partner for the US, and thus a change in the trade flows with Bolivia is of minor impact on the US economy.[7] These results provide the first indication as to which of the three scenarios would be the most advantageous for Bolivia in terms of economy-wide enrichment.

The size of changes in welfare and GDP under the first two scenarios, though positive, is not considerable. In fact, such changes suggest quite moderate gains resulting from the trade reforms. This is because the trade policy measures simulated consisted on lowering import tariffs to just 40% of all Bolivian commodities exported into the US (the remaining 60% already enters duty-free under the ATPDEA). Also, Bolivia has maintained relatively low protection measures to US products, with tariffs uniformly set at 10%, with exemptions on capital equipment (5% tariff), and books and publications (2% tariff). Moreover, the use of the Armington structure in the GTAP model tends to display, when one country reduces its tariff rates, reduced terms of trade effects and small resource reallocation across industries. For those reasons, the removal of such low and limited tariffs would not generate large changes in GDP or aggregated welfare.

Changes on Exports

The overall Bolivian exportable production of labor-intensive manufactures would increase in the first and second scenarios, and decrease in the third one. That is, as US import tariffs of these manufactures are reduced, the US substitutes towards labor-intensive manufactures from Bolivia relative to other countries.

Bolivian exports of other sectors such as agriculture, mining, capital intensive manufactures and services under Scenarios 1 and 2 would decline, as implied by negative values in Table 7. This decline in exports is because most of these commodity groups were already tax-free in the pre-reform scenario and, thus, the change in prices of these Bolivian commodities in the US markets only slightly changed. Additionally, the aggregate commodities import price into the US would not change because the share of Bolivian exports into US markets is relatively insignificant.

[7] US imports from Bolivia in 2005 were worth about USD 308 millions, which represented just 0.02% of total US imports.

Table 7. Percentage Change in Bolivian Export Sales

Commodity group	Scenario 1 FTA	Scenario 2 Restricted FTA	Scenario 3 No ATPDEA
Agriculture	-3.4	-2.6	1.3
Mining	-2.4	-1.9	1.1
Manuf. intensive in natural resources	21.4	-2.8	1.6
Manuf. intensive in labor	20.5	21.2	-22.4
Manuf. intensive in capital	-3.2	-2.5	1.6
Services	-2.9	-2.4	1.2

In the third scenario, the Bolivian exports of labor intensive manufactures substantially decreased (-22.4% per year). The reason behind this is found in the tariff reform under Scenario 3, which assumed that trade preferences the US gives to Bolivia are eliminated. This would cause tariffs of Bolivian labor-intensive manufactures to increase, making these products more expensive in US markets. This is reflected by the substitution effect, which implies a substitution of Bolivian manufactures by cheaper and more competitive suppliers of these products.

Considering the expansion in Bolivian exports to the US in some commodity groups and the contraction in other groups, in overall terms, Bolivian exports to the US would grow annually by 14.2% and 11.1% in the first and second scenarios respectively, and would decrease by 5.8% per year if the ATPDEA is eliminated (Table 8).

This growth in the first two scenarios would occur at the expense of export reductions to other countries (ranging between -3.0% and -0.6% in the first scenario, and between -2.3% and -0.5% in the second one). In the third scenario, Bolivian exports to the US would decrease, while exports to other regions of the world would increase in modest percentages, ranging between 0.3% and 1.5%. The structure of Bolivian exports would not experience abrupt changes in comparison with the pre-simulation scenario (Table 9). That is, Bolivia would continue exporting products with a relatively low degree of transformation (such as mining products that include natural gas) and goods with a relatively high content of natural resources.

Table 8. Change in Bolivian Exports by Trade Partner

Country	Scenario 1 FTA		Scenario 2 Restricted FTA		Scenario 3 No ATPDEA	
	Value (million USD)	% change	Value (million USD)	% change	Value (million USD)	% change
United States	35.5	14.2	27.8	11.1	-14.4	-5.8
Argentina	-2.0	-3.0	-1.5	-2.3	1.0	1.5
Venezuela	-2.2	-1.2	-1.7	-1.0	1.0	0.6
Colombia	-1.9	-1.5	-1.5	-1.2	0.9	0.7
Brazil	-1.6	-0.6	-1.2	-0.5	0.7	0.3
Peru	-1.2	-2.0	-0.9	-1.6	0.5	0.9
Chile	-0.7	-2.5	-0.6	-2.0	0.4	1.2
Ecuador	-0.4	-1.6	-0.3	-1.3	0.2	0.8
EU	-4.6	-1.9	-3.7	-1.5	2.1	0.9
ROW	-5.3	-1.3	-4.2	-1.1	2.5	0.6
Total	15.7	1.0	12.1	0.8	-5.2	-0.3

Table 9. Bolivian Exports by Sector of the Economy

Commodity sector	Base Scenario (pre-simulation)		Scenario 1 FTA		Scenario 2 Restricted FTA		Scenario 3 No ATPDEA	
	USD	Share (%)	USD	Share (%)	USD	Share (%)	USD	Share (%)
Agriculture	95	5.8	93	5.7	94	5.7	95	5.9
Mining	467	28.7	466	28.4	466	28.5	467	28.9
Manuf. int. in nat. resources	340	21.0	345	21.0	337	20.6	343	21.1
Manuf. intensive in labor	209	12.9	235	14.3	237	14.5	195	12.0
Manuf. intensive in capital	287	17.6	279	17.0	281	17.2	291	17.9
Services	227	13.9	222	13.6	223	13.6	229	14.2
Total	1,625	100.0	1,641	100.0	1,637	100.0	1,620	100.0

Changes on Imports

The reduction of import tariffs between Bolivia and the United States would increase the demand for imports from the US at the expense of imports from other regions (Table 10). Under a full FTA (Scenario 1), the value of Bolivian imports from the US would grow annually by 46%. This growth would be at the expense of reductions in imports from other sources. Given that Brazil and Argentina hold such large shares in the structure of Bolivian imports, these two countries would suffer the most from trade diversion. The large increase in Bolivian imports from the US overcomes the reduction of Bolivian imports from other sources, yielding a net increment of 2.3% in the value of total imports.

Under a restricted FTA (Scenario 2), the substantial growth in the value of Bolivian imports from the US (43%) would also reduce imports from other countries of the world, yielding a net increase in the value of total imports of 2.1%. If the ATPDEA is eliminated (scenario 3), Bolivia would import less from all countries included in this regional aggregation, resulting in a net reduction in the value of total imports of 0.5%. These changes in imports are explained by the difference between these scenarios. That is, when comparing the first and second liberalization scenarios, the second one imposes quantitative restrictions for sensitive products, which lower the possibilities of increasing the exchange of

Table 10. Change in Bolivian Imports by Trade Partner

Country	Scenario 1 FTA		Scenario 2 Restricted FTA		Scenario 3 No ATPDEA	
	Value (million USD)	% change	Value (million USD)	% change	Value (million USD)	% change
United States	125.3	46.3	116.7	43.1	-1.1	-0.4
Argentina	-11.8	-4.3	-10.1	-3.7	-1.0	-0.4
Venezuela	-0.9	-5.4	-0.9	-5.5	0.0	-0.2
Colombia	-2.1	-4.4	-2.1	-4.5	-0.2	-0.5
Brazil	-21.6	-5.8	-21.0	-5.6	-1.8	-0.5
Peru	-4.2	-4.1	-3.8	-3.7	-0.5	-0.5
Chile	-5.4	-3.3	-5.2	-3.2	-0.9	-0.5
Ecuador	-0.3	-4.4	-0.3	-4.0	0.0	-0.6
EU	-17.9	-6.3	-18.2	-6.4	-1.4	-0.5
ROW	-16.9	-4.8	-16.3	-4.6	-1.9	-0.6
Total	44.2	2.3	38.8	2.1	-8.8	-0.5

commodities. In the third scenario, US import tariffs for some Bolivian products actually increase, which further restricts the possibilities of exchanging products between both countries. Considering sharper increases in imports relative to exports, the Bolivian trade balance would experience a deficit of about 1.4% and 1.3% under Scenarios 1 and 2 respectively, while a positive (although negligible) trade balance of 0.12% would occur under Scenario 3 (results not shown here).

Under Scenarios 1 and 2, Bolivia would reduce tariffs to US commodities, lowering US imported supply prices. This would make US products more competitive and provide an incentive to Bolivian firms, households and government to increase their imports of intermediate products and goods for final consumption. Sensitivity analyses were conducted to evaluate changes in the Armington elasticities values, which are key elements in the determination of the trade results.[8] Simulations indicated that regardless of whether the Armington elasticities increased or decreased, the results would not change in qualitative terms. That is, gains in both welfare and GDP were always higher in Scenario 1 in comparison with Scenario 2, while Scenario 3 represented in all cases the worst case for Bolivia.

MICRO RESULTS

This section turns to the micro-simulation results to investigate the impact of the three trade scenarios on the different type of households in Bolivia.

Market Price Changes by Type of Trade Reform

Table 11 shows that prices of commodities decline under the first two scenarios, and increase under the third one for most sectors. These results were expected given that the first two scenarios reduce import protection tariffs, which would push down domestic prices and promote wider competition from abroad. However, results show that such reductions in tariff protection would not produce large reductions in domestic prices, but moderate ones because of the relatively low rates of protection in Bolivia. Under the elimination of the ATPDEA, changes in most commodity prices would be positive, though negligible. That is because in this scenario Bolivia does not change its protection tariffs, while the US increases import tariffs for some Bolivian products (no ATPDEA), resulting in negligible price impacts in Bolivia.

[8] A dynamic model would have led to further insights evaluation of tariff elimination for sensitive products over time. However, the dynamic GTAP model and database do not include Bolivia as an individual country (the dynamic model is not based on version 6.2 of the GTAP database that was used in this research, but on version 5.0, with base year 1997). This database limitation does not allow evaluating the specific impacts of a FTA on the Bolivian economy. In addition, the focus of our research was to use the macro-micro approach to evaluate poverty effects. For that, we would like to know the "cumulative" poverty impacts of trade liberalization, for which the static model serves our purpose.

Table 11. Changes on Commodity and Production Factors Prices in Bolivia (in Percentage Changes)

Sector	Scenario 1 FTA	Scenario 2 Restricted FTA	Scenario 3 No ATPDEA
Agriculture			
Rice	-0.03	-0.00	0.00
Wheat	-1.27	-0.00	0.00
Cereals	-2.04	-2.04	0.00
Vegetables, Fruits and Nuts	-0.69	-0.69	0.00
Oil Seeds	-0.01	-0.00	0.00
Other Agriculture	-0.74	-0.73	0.00
Raw Milk	-0.00	-0.00	0.00
Animal	-0.59	-0.59	0.00
Fishing	-0.02	-0.02	0.00
Mining			
Gas	-3.38	-3.38	-0.00
Energy	-0.95	-0.95	-0.00
Mining	-1.90	-1.90	0.00
Manufactures intensive in natural resources			
Meat	-0.95	-0.95	0.00
Vegetable Oils and Fats	-0.09	-0.09	0.00
Dairy Product	-0.26	-0.00	0.00
Food Products	-0.51	-0.50	0.00
Sugar	-1.04	-1.03	0.00
Manufactures intensive in labor			
Textiles	-0.62	-0.00	0.00
Apparel	-0.78	-0.78	0.00
Leather Products	-0.44	-0.00	0.00
Wood Products	-1.22	-1.22	0.00
Other Light Manufacturing	-1.09	-1.09	0.00
Manufactures intensive in capital			
Petroleum and Coal Refinement	-0.11	-0.11	-0.00
Chemical, Rubber and Plastic	-0.88	-0.88	0.00
Metals Nec	-1.00	-1.00	-0.00
Metal Products	-0.93	-0.93	0.00
Motor Vehicles	-1.43	-1.43	0.00
Machinery and Equipment	-2.69	-2.69	0.00
Services			
Services	0.00	0.00	0.00
Production factors			
Land	-0.27	-0.41	0.15
Unskilled Labor	1.07	0.90	-0.40
Skilled Labor	1.08	0.91	-0.38
Capital	0.95	0.78	-0.34
Natural Resources	-1.85	-1.68	0.86

The trade policy scenarios on the income side result in mixed effects for Bolivian production factors (bottom part of Table 11). While there are price reductions in returns to land and natural resources under Scenarios 1 and 2, there are increases in returns to all other production factors (i.e., unskilled labor, skilled labor and capital). In the case of the third scenario, results are the opposite. That is, there are positive changes in returns to the use of land and natural resources and negative returns to unskilled labor, skilled labor and capital.

These results are mainly explained by the way in which we modeled changes in demand for some endowment factors in the GTAP model. That is, we assumed that land and natural resources were sluggish factors, meaning that these are sector specific and do not move between sectors. Results show that demand for both land and natural resources decreased in the first two scenarios implying, in the face of a very inelastic supply curve, a reduction in the price of land and natural resources. In the third scenario, there is an increase in the demand for land and natural resources, which leads to an increase in their relative prices.

With regard to unskilled and skilled labor and capital, they are assumed to be mobile factors, with a more elastic supply curve. There is an increase in the demand for these factors under the first two scenarios, which increased their prices. The opposite occurs in the third scenario, where demand for these three production factors is reduced, leading to a reduction in their relative prices.

Changes in Income and in Expenditures by Production Factor

Overall results of the impacts of the trade reforms on households' private utility by production factor indicate that, under the first two trade liberalization scenarios, private utility would increase for households depending on all production factor categories, except for agriculture-dependent households (Table 12). If the ATPDEA is eliminated (Scenario 3), private utility would increase only for agriculture-dependent households, and decrease for all other factor-dependent households. The rise in private utility in all production factors (except agriculture under Scenarios 1 and 2) is explained by increased returns to production factors, as reflected by Laspeyres index for income's values greater than 100, and by reduced commodity prices that reduce households' expenditure on their consumption bundle (reflected by values of the Laspeyres index for expenditure lower than 100).

Private utility was projected to be, for most production factors, somewhat higher in Scenario 1 than Scenario 2. This is because returns to factors of production (i.e. unskilled labor, skilled labor and capital, bottom part of Table 11) tend to grow at a faster rate in Scenario 1 relative to Scenario 2. In the third scenario, the drop in private utility for all households, except Agriculture, is explained by declines in returns to their factors of production, which were not compensated by changes in the cost of the consumption bundle. This would result in a decline of net income and hence a reduction in private utility.

Table 12. Impacts of Trade Reform Scenarios on Household Private Utility by Production Factor

Production factor	*Laspeyres* index for income			*Laspeyres* index for expenditure			Private utility (percentage change)		
	FTA	Restricted FTA	No ATPDEA	FTA	Restricted FTA	No ATPDEA	FTA	Restricted FTA	No ATPDEA
Agriculture	98.33	99.01	100.55	99.76	99.40	100.00	-1.42	-0.39	0.55
Non-agriculture	100.65	100.49	99.33	99.36	99.37	100.00	1.30	1.12	-0.67
Capital	100.86	100.69	99.49	99.36	99.38	100.00	1.50	1.32	-0.51
Natural resources	101.00	100.83	99.65	99.36	99.37	100.00	1.64	1.46	-0.35
Diversified	100.86	100.69	99.48	99.36	99.38	100.00	1.50	1.32	-0.52

Changes in Income and Expenditure by Income Level

Table 13 summarizes results of household private utility by income level, showing that as a consequence of the full trade liberalization (Scenario 1), private utilities of household heads included in the income categories III, IV, V and VI would increase, while the private utility of the two poorest households would decrease. Under the restricted FTA scenario, the private utility of all household groups (except the poorest income group) would increase. Meanwhile, under Scenario 3 (no ATPDEA), only private utility of household heads belonging to the poorest income category would increase, while private utilities of the rest of the income groups would decrease. An interesting finding emerging from this household classification criterion is that private utility for the first two scenarios decreases for the poorest households and increases for the better off household groups, widening the income gap in a country where income is already badly distributed (UDAPE, 2006).

The results of the third scenario indicate that households belonging to the poorest income group would be better off as a result of the end of the ATPDEA. However, this group represents only a fraction of the whole sample population (table 4), and considering that more than half of Bolivia's population is estimated to be poor (60% according to official Bolivian sources), it is not convenient to consider the end of the ATPDEA as a good policy option for the Bolivian society as a whole. Such termination would make worse off households in income categories II, III and IV, where the majority of the Bolivian poor are. In addition, almost all household included in the poorest income group are farmers, whose food consumption is significantly satisfied (25% on average) with own agricultural production. Such production is not entirely subject to changes in prices of agricultural commodities, and thus their food security is more certain relative to the poor living in the peri-urban and urban areas of Bolivia (who are mostly in income categories II to IV).

Table 13. Change in Private Utility by Income Category (Percentage Change)

Income group	Income Range (Bs/month)	Scenario 1 FTA	Scenario 2 Restricted FTA	Scenario 3 No ATPDEA
I	<= 390	-1.03	-0.88	0.34
II	390 – 695	-0.58	0.40	-0.22
III	695 – 1,033	1.64	1.45	-0.37
IV	1,033 – 1,538	1.66	1.47	-0.38
V	1,538 – 2,547	1.68	1.50	-0.38
VI	2,547+	1.70	1.52	-0.38

Note: Income levels are expressed in Bolivianos per month (Bs/month). For the first income category 390 Bs/month (or less) and considering the average exchange rate in 2002 (1 USD = 6.9 Bolivianos), this corresponds to 56 USD/month.

Own production is not only important in Bolivia; Arndt (2005) found that in Mozambique roughly half of all measured consumption was supplied by own production. He found that households operating on this type of subsistence basis were less integrated into the domestic economy, so the possibility of them being influenced by changes in domestic prices was reduced. Considering that most household groups would benefit under Scenarios 1 and 2, where the majority of the Bolivian poor are included, the termination of trade preferences provided by the US to Bolivia (Scenario 3) would not be the best option for the Bolivian society as a whole.

CHANGES IN INCOME AND IN EXPENDITURE BY GEOGRAPHIC LOCATION

Another perspective is given by analyzing private utility results classified by geographical location. For this, we positioned private utility results according to a one-percent positive or negative threshold approach, as follows:

- Winner (W): a household is a 'winner' if the average household private utility increases by more than 1%;
- Marginal Winner (MW): a household is a 'marginal winner' if the average household private utility increases by less than 1%;
- Loser (L): a household is a 'loser' if the average household private utility decreases by more than 1%;
- Marginal Loser (ML): a household is a 'marginal loser' if the average household private utility decreases by less than 1%.

We only discuss the first two scenarios, as the third one has been found to be disadvantageous for Bolivia (Table 14). Under Scenario 2, the benefits that a Restricted FTA would accrue to household groups would be more evenly distributed. Not many 'winning' households were projected in this scenario (just 2), and just one 'marginal loser' household area was projected. The majority of the household areas (15 in total) were projected to be 'marginal winners', meaning that they would benefit from a restricted FTA, but those benefits would be smaller than in Scenario 1, and more equably distributed across more household group areas.

Scenario 2 implies that the distribution of trade benefits between urban and rural areas narrows at least in the poorest region of Bolivia. That is, rural and urban households of the poorest region of the country (the Altiplano region comprising La Paz, Oruro and Potosí) benefit from the Restricted FTA. This situation was not projected to happen under Scenario 1, but on the contrary under this scenario more benefits would go to urban households and less to rural ones. A large share of total population in the Altiplano region live in rural areas (46% on average or 1,533,000 people), indicating that impacts are important in terms of total number of households involved.

More than half of total population of Chuquisaca and Potosí ('Losing' areas under Scenario 1) live in rural areas (55% or 332,000 people in Chuquisaca, and 65% or 503,000 people in Potosí), implying that Scenario 1 of trade liberalisation would negatively affect large numbers of people in Chuquisaca and Potosí. Also, a large share of total population in Oruro and Tarija ('Marginal losers' under Scenario 1) live in rural areas (39% or 265,000 people in Oruro, and 34% or 433,000 people in Tarija), indicating that Scenario 1 would also be detrimental for rural households in these two departments.

Table 14. Mapping of Impacts of Trade Reforms in Bolivia under Scenarios 1 and 2

Situation	Scenario 1 FTA		Scenario 2 Restricted FTA	
	Urban	Rural	Urban	Rural
Winner (W)	**5**: Cochabamba, La Paz, Pando, Beni and Santa Cruz	**1**: Beni	**2**: Beni and Santa Cruz	**0**
Marginal Winner (MW)	**4**: Oruro, Potosí, Chuquisaca and Tarija	**4**: Pando, La Paz, Cochabamba and Santa Cruz	**7**: Chuquisaca, Cochabamba, La Paz, Oruro, Pando, Potosí and Tarija	**8**: Beni, Chuquisaca, Cochabamba, La Paz, Pando, Potosí, Santa Cruz and Tarija
Marginal Loser (ML)	**0**	**2**: Oruro and Tarija	**0**	**1**: Oruro
Loser (L)	**0**	**2**: Potosí and Chuquisaca	**0**	**0**
Total	**9**	**9**	**9**	**9**

Note: 18 household areas correspond to Bolivia's nine departments split in rural and urban areas. A department is a first-level political division in Bolivia. A 'household area' refers to a geographical location where the average household is 'winner', 'loser', 'marginal winner' or 'marginal loser'.

These findings suggest that the complete liberalization of the economy (Scenario 1) would result in broad-based increases in utility for some household areas, while the sector-specific measures (Scenario 2) would yield smaller but more complete economy-wide benefits for most household areas. From an economy-wide and benefit-distribution point of view, Scenario 2 seems to be the most expedite and beneficial for Bolivia. The worst scenario is the elimination of trade preferences from the US, where most Bolivian households would experience reductions in private utility.

Conclusions and Further Research

The general conclusion of this research is that Bolivia's efforts to reach a trade agreement with the US would pay off. While the FTA scenario was identified as the most profitable trade setting for the Bolivian economy as a whole, a restricted FTA, which considers sensitive commodities, was found to be the most prudent and advantageous trade setting for the Bolivian society as benefits would be distributed across more household groups. Meanwhile, the end of US trade preferences to Bolivia under the ATPDEA would be the worst case for both the Bolivian macroeconomic performance and the economic wellbeing of its households.

A key reason why a restricted FTA is preferable to a complete FTA is because of the disparity in benefits distribution under a full FTA. That is, under this scenario many Bolivian poor would lose, while the better off households would win. This outcome would further worsen income distribution in Bolivia, a country with a large income gap between the rich and the poor. The restricted FTA would provide a more even distribution of trade benefits for more households, and thus appears a better option for Bolivian society as a whole.

The main implication of this research is that Bolivia should not remain apart from the processes and economic dynamism that characterize the current wave of trade liberalization. Protectionist trade policies and end of trade relations with the US have to be avoided if economic growth and household wellbeing are to be improved. Bolivia has to advance with caution and based on a negotiation strategy that provides protection to certain commodities, while strengthening major exporting sectors.

Additionally, the Bolivian government with the help of international institutions and donors should implement domestic policies to compensate losers of trade liberalization. Such policies should include income transfers, especially for those sectors hardest hit by trade liberalization. An example of such a program is PROCAMPO, a program for the poor in Mexico to help them cope with increased competition from the US and Canada, and help them transition from, for example, traditional staple production to high value added products. Other programs, already implemented in many developing countries include direct income transfers and directed subsidies to poor households. At the same time, such policies should not have major impacts on domestic prices and consumption decisions of other population segments, and should not put an additional burden on Bolivia's budgetary restrictions and economic goals.

Extensions for further research could include incorporating price transmission and replacement of tariff revenues. Both would involve estimating how much of the changes in international prices would be transmitted to domestic urban and rural markets and how governments would need to increase domestic taxes (such as VAT or income taxes) to compensate for fiscal deficits resulting from lost tariff revenue, bearing in mind the lack of institutions and market mechanisms in developing countries to do this (it might be difficult in developing countries to collect taxes because of limited capacity of people to pay taxes; therefore, investigation on the extent to which governments will be able to collect more taxes to replace loss in tariff revenues might be needed). The micro-simulation approach used in this research has the virtue of being operational across a wide range of household surveys that contain information on prices and quantities of commodities and production factors. It has been implemented with data on about 5,700 households, and could readily be applied to other surveys (and countries) that contain solely information on prices and quantities. This approach resolves, in a computationally explicit way, the evaluation of the economic wellbeing impacts of trade policy reforms.

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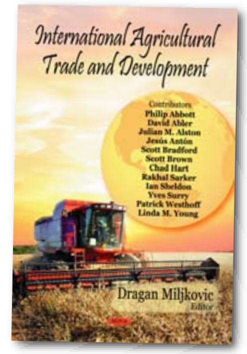

Binding: Hardcover ISBN: 1-60021-965-9
Pub. Date: 2007 Price: $69.00

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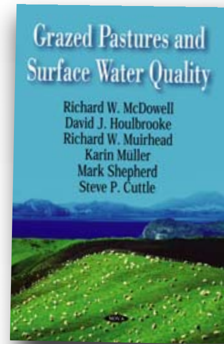
Grazed Pastures and Surface Water Quality



Richard W. McDowell
David J. Houlbrooke
Richard W. Muirhead
Karin Müller
Mark Shepherd
Steve P. Cuttle

This book examines the role grazed pastures have on surface water quality. Land used for livestock industries occupy 70% agricultural land and produces 40% of agricultural gross domestic product. Increasing populations and incomes, coupled with a change in diets and urbanisation in the developing world, is enhancing demand for pasture-based products. To meet these demands, most efforts will go into intensification of improved pastures or the development of new areas previously too marginal to farm. This will change biodiversity above and below the ground, affecting the chemical and physical properties of the soil, which combine to alter the potential for contaminant transfer to surface water. To negate any detrimental effects on surface water quality we have to improve the cycling of nutrients on-farm, the efficiency of pastoral production systems, and break transmission routes to surface waters or among units of the farm (e.g., zoonoses). To address this, our book focuses on major contaminants impacting surface water quality via intensively grazed pastures, namely, phosphorus, nitrogen, sediment, pesticides and faecal bacteria. The text is a valuable resource for scientists, policy makers and students alike.

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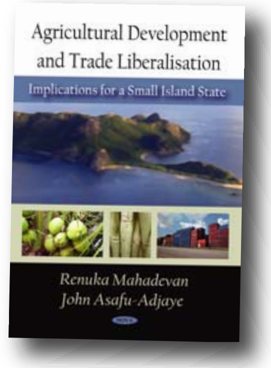
Agricultural Development and Trade Liberalisation

Implications for a Small Island State

Renuka Mahadevan
John Asafu-Adjaye



This book brings empirical analysis to bear on the policy debate on the economic and environmental impacts of agricultural trade liberalisation on a small developing country, represented by the island of Fiji. It is timely because many African, Caribbean and Pacific (ACP) countries are faced with challenges in the years ahead as a result of globalisation and liberalisation of world trade. Some ACP countries, including Fiji, have already signed an interim Economic Partnership Agreement (EPA) with the European Union to replace the Cotonou Agreement. Other future changes in the trading regime are likely to come from the eventual conclusion of the Doha Round. What is lacking in the current debate is solid empirical analysis to investigate the impacts of these policy changes. What little analysis has been carried out lumps developing countries into regional aggregates. Thus, it may be argued that these studies do not take account of the individual countries' circumstances.

The book focuses on the sugar industry to discuss the broad topic of agricultural reform. Quantitative and qualitative methods are used to support the analysis and discussion in the areas of structural reform in the sugar and other industries as well as the effects of trade liberalisation strategies. The empirical investigation is carried out using appropriate econometric techniques and a dynamic computable general equilibrium model. The material is presented in such a way that the non-technical reader will also benefit from the discussion, which has policy making as its focus.

It should appeal to a wide readership including policymakers, policy analysts, researchers in industry and the public sector, as well as postgraduate students in various fields such as agriculture and natural resources, international trade, and economic modelling.

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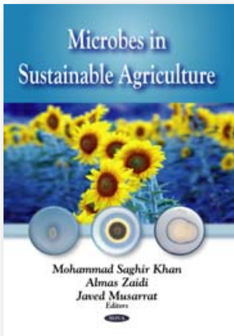

Microbes in Sustainable Agriculture

Mohammad Saghir Khan
Almas Zaidi
Javed Musarrat
Editors

The major aim of "microbes in sustainable agriculture" is to provide unique collection of data and a holistic view of the subject while presenting more current ideas in the field where significant advances have been made. Collectively, this book provides recent coverage of the role of microbes in sustainability of agronomic practices and thus is likely to be of tremendous value to the students, scientists, teachers of microbiology, biotechnology, environmental biology, agronomy, plant physiology and plant protection, who are interested in this area.

Each chapter in this book has been contributed by a qualified team of teachers/scientists. In this context, the current state of knowledge in a specialized field is reviewed without compromising the basic conceptual frame work presented in this book. A concerted effort has been made by editors/authors to bring in quality presentation. This book thus addresses a lot of common queries and of course some odd ones that bring an interesting approach to problems solving in agricultural practices with optimum application of diverse microbes. This book presents readers with stimulation to forge thought in a non-conventional way to understand complex issues as it addresses many problems previously ignored. This book serves as an important source because of its unique compilation of data and text on the application and importance of microbes in crop productivity to achieve global food security.

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