IMPACT OF AGRICULTURAL PRODUCTIVITY CHANGES ON AGRICULTURAL EXPORTS

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Ananda Bahadur Gurung

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Agribusiness and Applied Economics

December 2008

Fargo, North Dakota

North Dakota State University

Graduate School

Title

Impact of Agricultural Productivity

Changes on Agricultural Exports

By

Ananda Gurung

The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

ABSTRACT

Gurung, Ananda Bahadur, M.S., Department of Agribusiness and Applied Economics, College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, December 2008. Impact of Agricultural Productivity Changes on Agricultural Exports. Major Professor: Dr. David Lambert.

This study uses linear programming and econometric tools to determine the impact of agricultural productivity (technology) on agricultural exports. The study determines total factor productivity (TFP) using the Malmquist index method for a panel of 64 countries. Productivity impact on exports is determined by a two-stage estimation procedure.

The results show agricultural productivity affects agricultural exports. This has important implications for developing countries. A 1 unit change in cumulative TFP increases agricultural output by .79%, and a 1% increase in estimated agricultural output increases exports by .37%. Therefore, the total effect of technology on exports of primary and processed commodities is .29%. Developed countries generally have higher TFP rates, leading to higher export earnings; meanwhile, developing countries are not getting the benefits from agricultural exports because they have a relatively lower level of agricultural productivity. Investing in research and development for agriculture can improve technology, which, in turn, can increase agricultural exports.

ACKNOWLEDGEMENTS

I would like to thank my adviser, Dr. David Lambert, for his guidance and help. I would also like to thank my committee members, Dr. Saleem Shaik, Dr. John Bitzan, and Dr. Dragan Miljkovic, for their time and support to provide insight and assistance. I would also like to appreciate my friends for their support and suggestions: Denee Janda, Chris Whaley, and Alyssa Tangen. Finally, I would like to thank my family members for their support throughout my education and other endeavors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

CHAPTER 1. STATEMENT OF PROBLEM

1.1. Background

Trade liberalization increased the flow of international goods, services, and capital after WWII. Agricultural trade, despite trade restrictions, also increased. Policy changes, especially formed as part of international trade negotiations, have played a major part in bringing in this trade liberalization. According to the World Trade Organization (WTO, "GATT", n.d.), the most important international trade negotiations for agricultural trade took place in the Tokyo and Uruguay Rounds. In 1973, the Tokyo Round of international trade negotiations began. From 1973-1979, 102 countries participated. The Tokyo Round had some success cutting tariffs in the industrial sector but had mixed results in agricultural trade. The focus of reducing trade barriers in agriculture continued in the Uruguay Rounds. The Uruguay Rounds produced comprehensive reforms in both general and agricultural trade.

The Uruguay Rounds started in September 1986 and continued until April 1994 with 123 countries participating in this trade negotiation. The objective of this round was to reform the trade sector and make trade policies more market oriented. The WTO ("Agriculture", n.d.) itemized the new rules of this round, which are focused on three areas:

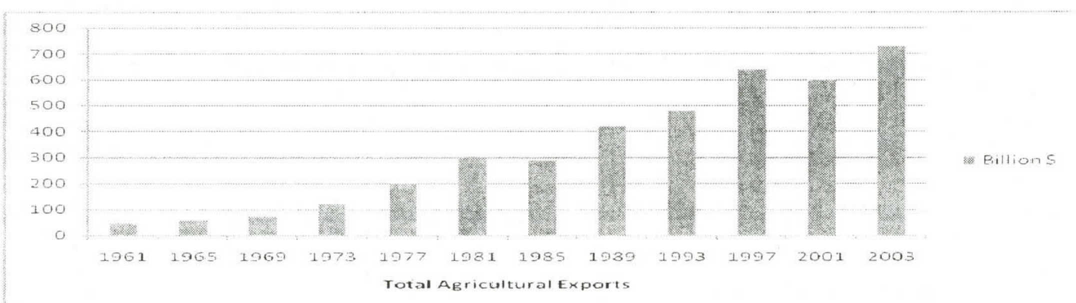
a) <u>Market access</u>: various trade restrictions facing imports;

b) <u>Domestic support</u>: subsidies and other programs, including those that raise or guarantee farm rate prices and farmers' incomes; and

c) <u>Exports subsidies</u>: which make exports artificially competitive.

Developing countries did not have to cut their subsidies and tariffs as much as developed nations. The least developed countries did not have to lower their subsidies and tariffs at all. The Uruguay Rounds also eliminated the use of quotas as a trade barrier. Developed countries decided to cut their tariff rates on all agricultural commodities of 36% over a 6-year period from 1995-2000. Developing nations agreed to lower the tariff rates by an average of 24% over a 10-year period from 1995-2004. Developed nations agreed to lower their domestic and export subsidies by an average of 20% and 36%, respectively. For developing nations, the reductions were an average of 13% and 24%, respectively. The latest round of talks in the WTO is the Doha Round which started in November 2001 and is ongoing. Its main purpose is to lower trade barriers so that countries can increase trade globally (WTO, "Agriculture", n.d.).

Figure 1 shows real international exports in agricultural products from 1961 to 2003.



Adapted from Food and Agriculture Organization (FAO) of the United Nations (2005).

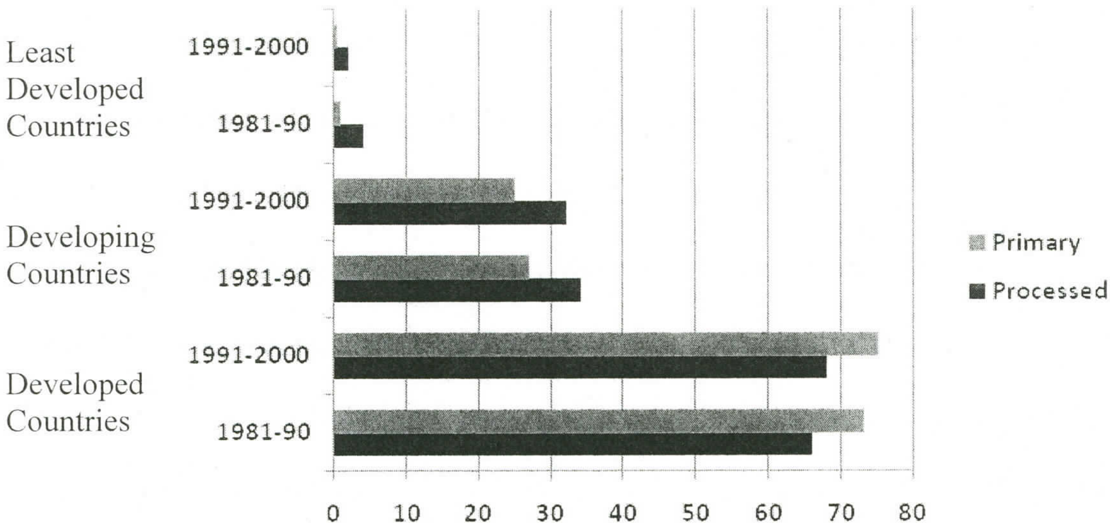
Figure 1. Total Agricultural Exports.

As seen from Figure 1, total agricultural exports rose during that period. In 1961, the total agricultural exports were about two billion dollars. By 2003, total agricultural exports increased to more than 700 billion dollars.

The expansion of trade has benefits for both importing and exporting countries. Expanded trade can increase real purchasing power and gross domestic product (GDP), reduce poverty by increasing wages, and open new markets in developing countries (Thompson, 2007). Purchasing power increases as goods become cheaper due to international trade. Countries engage in trade to obtain goods and services that other countries can produce at a lower cost. Trade can reduce poverty by increasing wages in low-income countries. When income increases, people's purchasing power increases. When people's purchasing power is increased, the domestic market for foreign products, which may be produced at a lower cost, increases. When countries engage in international trade, each nation has incentives to move its resources into the highest-value uses which, in turn, helps to create economic growth. Countries produce more GDP from their land, labor, and capital because they are not using these resources to produce goods that other countries can produce at a relatively lower cost (WTO, 2008).

The distribution of agricultural export gains has not been uniform among participants, however. A number of studies and reports show that there is a disparity of agricultural exports between developing and developed nations (Food and Agriculture Organization of the United Nations [FAO], 2004, 2005; Athukoral & Sen. 1998). During the last four decades, developing countries' share of world agricultural exports declined from almost 40% to about 25% (FAO, 2005). An increasing share of global agricultural exports has come from developed nations. The European Union's share of total agricultural exports, for example, increased from about 20% in the early 1960s to more than 40% today (FAO, 2005).

Even though total agricultural exports have been increasing in both developing and developed nations, the disparity between the increase in the two groups' total agricultural exports is large. For developed countries, total agricultural exports in 2003 reached about 500 billion U.S. dollars (FAO, 2004). In comparison, developing countries' total exports were about 200 billion U.S. dollars. A graph of the developing and developed countries' shares in exports of primary and processed agricultural products for the periods 1981-1990 through 1991-2000 is presented in Figure 2 (FAO, 2005).



Adapted from Food and Agriculture Organization (FAO) of the United Nations (2005).
Figure 2. Developing and Developed Country Share in Exports of Primary and Processed Agricultural Products from 1981-1990 to 1991-2000.

As seen from Figure 2, the shares in exports of primary and processed agricultural products are small for developing countries in comparison to the developed countries. For developed countries, the shares of world agricultural exports for primary and processed products were about 68% and 74%, respectively, in 1991-2000. For the developing countries, the shares of world agricultural exports for primary and processed products were about 25% and 33%, respectively, in 1991-2000. For the least-developed countries, the shares for both processed and primary agricultural products were less than 10% in 1991-2000.

1.2. Problem Statement

Disparities in the agricultural exports among developed and developing nations have significant economic impacts. This is especially true for the poorer nations because agriculture still constitutes a large portion of their total GDP. In 2005, agriculture represented 21.1% of the total GDP in low-income countries, 9.1% of the total GDP in middle-income countries, and 1.5% of the total GDP in high-income countries (World Resource Institute, 2007). The benefits lost due to limited increases in international agricultural exports include higher foreign currency earnings, greater GDP, economic growth, rising income, and greater purchasing power parity (Thompson, 2007; WTO, 2008). Lower agricultural exports also increase food insecurity for developing countries (FAO, 2005). In 2003, developing countries earned 300 billion dollars less than developed nations in total agricultural exports (FAO, 2005).

Improvements in productivity underlie a country's exporters' ability to effectively compete in global markets. Links between productivity and exports have been supported by Wagner (2007); Arnade and Vasavada (1995); Delgado, Farinas, and Ruano (2002); Harrigan (1997); and Trefler (1995). The role of productivity gains in promoting agricultural exports among developed countries has recently been supported in work by Ghazalian and Furtan (2007), Gopinath and Carver (2002), and Weyerbrock (2001). However, there has been little empirical analysis about the impact of a country's agricultural productivity on exports that compares exports and productivity among developed and developing countries. Variability in agricultural productivity can change agricultural export patterns for both developing and developed nations, and this can have significant economic impacts, especially for developing countries.

1.3. Objective

The objective of this research is to measure productivity changes among a large number of developed and developing countries and to link productivity gains to changes in international agricultural exports.

1.4. Hypothesis

The hypothesis underlying the research is that positive change in agricultural productivity would have a positive impact on agricultural exports. This hypothesis assumes that increases in agricultural productivity, along with the increase of factor endowments of land, labor, capital, animal, and fertilizer inputs, increase total agricultural outputs. The resulting comparative advantage gained in agricultural output should increase total agricultural exports.

1.5. Organization

This study consists of five chapters. Chapter 1 is an introduction which includes a brief background on agricultural exports trend and their importance to developing countries. Chapter 2 focuses on the relevant literature of relationships between agricultural productivity and agricultural exports, and the different measures of computing agricultural total factor productivity (TFP). Chapter 3 describes data collection and estimation considerations, the method used to compute agricultural TFP, and the model used to describe the effect of agricultural productivity on exports. Chapter 4 presents Malmquist TFP results using data envelopment analysis (DEA) and the regression results for the relationship between agricultural exports and productivity. Chapter 5 concludes the study with a summary of the importance of the study, the Results, and their implications.

CHAPTER 2. LITERATURE REVIEW

This chapter discusses the existing literature that addresses three questions:

a) How does productivity affect exports?

b) How do exports affect productivity?

c) How is productivity measured?

2.1. How Does Productivity Affect Exports?

Arnade and Vasavada (1995) proposed that the Ricardian effect, as revealed through use of the general equilibrium model, explains the relationship between productivity and agricultural exports in Asia as well as Central and South America. In the production of certain goods, these countries are said to have a comparative advantage that is leveraged for exports upon any productivity increase. Productivity and exports of 16 Latin American countries and 17 Asian-Pacific Rim countries were analyzed based on data covering the period from 1961 through 1982. The authors found that only 3 of 33 countries showed productivity growth caused by increased exports. Their data also indicated that only 5 countries showed an increase in exports caused by an increase in productivity. Therefore, the authors concluded that the causal relationship (whether productivity causes exports or exports cause productivity) was unclear and inconclusive. The authors explain their findings by concluding that when there is productivity growth, domestic demand increases due to rising incomes of the host country's citizens.

Similar studies by Morley and Morgan (2008) and Kunst and Marin (1989) also examine the causal relationship between productivity and exports. Morley and Morgan (2008) looked at the causal relationship between exports and productivity, and between exports and agricultural support within the European Union. Using an autoregressive distributed lag (ARDL) approach, the authors showed that exports are enhanced by government support in Ireland and France, whereas productivity determines export growth in Germany and the UK. Kunst and Marin (1989) tested the causality relationship between exports and productivity of Austrian manufacturing firms. They used Granger causality tests to find the relationships between exports and productivity. Exports of manufactured goods, terms of trade (value of exports divided by value of imports), GDP of Organization for Economic Cooperation and Development (OECD) countries, and productivity (output per worker) were the variables used in the model. The results of the Granger causality test showed that exports do not cause productivity to increase. The tests did show that productivity increases exports in the manufacturing firms of Austria. However, the authors concluded that the result (exports do not increase productivity, but productivity increases exports) is preliminary, and further tests are needed on more developed and developing nations to verify the result.

Gopinath and Carver (2002) examined "the effects of technology and factor supplies (labor, capital) on specialization within agriculture" (p. 539). They attempted to find out how the United States and other developed countries gain comparative advantage in the processed food and agriculture sectors. The authors' objective was to understand how productivity increases, factor endowments, and linkages between the agriculture and food sectors can affect exports and the growth of agricultural and processed food sectors. Analyzing 13 OECD countries during a period of 20 years (1975-1995), the study showed that there are Ryczynski and Ricardian effects in both the agricultural and processed food trade. According to Suranovic (2004), the

Rybcznyski theorem implies "when there is an increase in the factor endowment of one particular factor in a country, that country will produce that good which uses that abundant factor" (para. 4). According to Griffin & Pustay (2005), the Ricardian theory of comparative advantage states "a country should produce and export those goods and services for which it is relatively more productive than other countries are and import those goods and services for which other countries are relatively more productive than it is" (p. 150). Both effects contribute to growth for the export shares of the agricultural and processed food sectors.

A similar study by Gopinath and Kennedy (2000) looked at how U.S. agricultural export levels are determined by an increase in productivity and factor accumulation. Examination of data from 23 years (1973-1996) and 48 states led to the conclusion that factor accumulation and factor productivity determine agricultural exports. If productivity increases, agricultural exports also increase.

Weyerbrock (2001) examined how productivity improvements impact both world agricultural markets and the agricultural exports of the former Soviet Union and Eastern Europe. A 6-region, 13-sector general equilibrium model was used. The study concluded that productivity increases lead to significant increases in a region's agricultural output and exports. Agricultural exporters benefit from productivity improvements, especially if productivity increases are not limited to agriculture.

Ludena and Hertel (2005) investigated how productivity increases in crops and livestock affect the world food sector. The authors used TFP measures in the Global Trade Analysis Project (GTAP) general equilibrium model to examine the role that different growth rates had in determining changes in world food export patterns between 1991 and 2001. The authors used the Malmquist measure of productivity. The authors hypothesized that productivity growth in crops and livestock helps create the "agroindustrial" sector. Raw agricultural commodities increase in value after they are converted into processed foods, which further increases a country's food trade with other nations. Results showed that technical change explains some variation in a country's trade mix, and TFP is one of the determinants which affect the change in trade shares.

Wagner (2007) provided a review of studies which use firm-level micro data to investigate the relationship between export activities and productivity. He looked at 54 empirical studies covering 54 countries, including both developed and developing nations. He posited two hypotheses. The first hypothesis said that firms enter the export market only after they become more productive (self selection). The assumption is that only productive firms can cover the additional costs of selling goods in world markets. Added costs can be for transportation and marketing, salaries, and modification of domestic products for foreign consumption. These costs become trade barriers, limiting entry to less successful firms.

Wagner's (2007) second hypothesis related to how firms become more productive after they start exporting (learning by exporting). Firms improve after exporting because knowledge flows through international trade with buyers and competitors. Based on Wagner's review, exporters are more productive than non-exporters, and the more productive firms self-select into export markets. Wagner said that most studies debate the second, learning-by-exporting, hypothesis. However, Wagner observed that it is still too early to conclude whether productivity improvements resulting from "learning by exporting" can be supported by the data.

Delgado, Farinas, and Ruano (2002) examined the differences in productivity of Spanish exporting and non-exporting firms for the period 1991-1996. The result indicated that exporting firms seem to have higher productivity than non-exporting firms. The authors found that productive firms enter the export market more than non-productive firms (self selection). They did not find strong evidence for a productivity increase after firms started exporting (learning by exporting).

2.2. How Does Trade Affect Productivity?

Previous studies also suggest that trade is a determinant of productivity. Miller and Upadhyay (2000) "study the effects of openness, trade orientation, and human capital on total factor productivity for a pooled cross-section, time-series sample of developed and developing countries" (p. 399). The authors first estimated TFP from a Cobb-Douglas production function which consists of output per worker, capital per worker, labor, and TFP with and without human capital. The authors then investigated the determinants of TFP. Explanatory variables included a ratio of exports to GDP, terms of trade, inflation rate, and their standard deviations over a 5-year period. The ratio of exports to GDP, terms of trade, and inflation rates were found to be significant in explaining TFP (Miller & Upadhyay, 2000).

The relationship between productivity and trade on non-agricultural sectors also suggested possible relationships between agricultural productivity and trade. A study by Loecker (2007) "analyzes the effects of exports on the economic performance of one of the most successful transition economies, Slovenia" (p. 90). Firm productivity and exports were seen to be correlated, but causation was initially unclear. Two possibilities were suggested: either the firms' increased productivity allows them entry into the export market (self selection) or the firms' productivity increases as a result of exporting (learning by exporting). The investigation was based on panel data consisting of productivity and export measurements for manufacturing firms during the period 1994-2000. Loecker found that firms increase their productivity once they enter the export market. These firms become 8.8% more productive, on average, after they start exporting in the short run and further experience productivity increases in the years after they decide to export. Firms that export to developed countries achieve a higher productivity growth. Their findings seem to support the learning by exporting hypothesis (Loecker, 2007).

A study by Fransisco and Ciccone (2004) looked at the impact of international trade on aggregate productivity of different countries. The authors defined "real openness" as a measure of trade. Real openness is defined as imports plus exports, expressed in U.S. dollars, relative to GDP in purchasing power parity, also in U.S. dollars. The cross-sectional data covered 1985 to 2000 and included observations of 47 countries. Using the real-openness measure, the authors found that trade is a causal factor for productivity, and this effect (trade causing productivity) is robust. They also found that, in international trade, a country's size also affects productivity. The authors concluded that additional investigation is needed to measure the extent to which trade policy affects productivity levels. This additional investigation would require the use of known exogenous variables (such as trade policy and geography) as the determinants for trade in the empirical analysis, and also the discovery or definition of new instruments for the measurement of endogenous trade.

A study by Bernard and Jensen (1999) examined whether exporting has contributed to increases in productivity growth in U.S. manufacturing. The data covered 1983 to 1992 and included approximately 55,000 plants in each year's data. An ordinary least squares (OLS) regression is used to find the relationship between exports and productivity. Bernard and Jensen's results found little evidence that trade increases productivity at individual plants. Instead, the authors found that the positive relationship between exports and productivity appears to show that high-productivity plants are more likely to enter the export markets. Exporting seems to reallocate resources from inefficient to efficient industries. The reallocation of the resources from the inefficient to efficient industries accounts for more than 40% of the productivity increase in the manufacturing sectors.

2.3. How Is Productivity Measured?

Indexes are most often used to measure TFP. Both parametric and nonparametric methods are used to calculate TFP. One of the most widely used measures is the Malmquist index. The Malmquist approach can distinguish two sources of productivity growth: changes in technical efficiency and technical change (Trueblood, 1996). There are several advantages when using a Malmquist TFP index (Lambert & Parker, 1998), including multiple input/output productivity measurements and reduced dependency on price data when weighting those measurements. Using price data in econometric analysis or in index numbers to find productivity can decrease accuracy because price data are often not reliable or might not be available for different firms. Lambert and Parker utilized the Malmquist TFP index approach to measure productivity changes using Chinese provincial agricultural data for the years 1978 to 1995.

Färe, Grosskopf, Norris, and Zhang (1994) showed how the Malmquist TFP index can be divided into efficiency change and technical change. Efficiency change shows "the change in relative efficiency (the change in how far observed production is from maximum potential production) between years t and t+1" (p. 71). Technical change is defined as "the shift in technology between two periods evaluated at the inputs x_t and x_{t+1}" (p. 71). Färe et al. used a nonparametric method to calculate the Malmquist TFP index for 17 OECD countries. GDP was used as the output. The inputs were capital and employment. The result showed that U.S. productivity growth is more than the average by a slight margin. The country which has the highest productivity growth is Japan. About 50% of Japan's productivity growth can be contributed to efficiency change (Färe et al., 1994).

Lissitsa, Rungsuriyawiboon, and Parkkhomenko (2007) computed Malmquist TFP index using a nonparametric distance function for 44 countries from 1992 to 2002. There were 25 European countries and 21 transition countries. According to the authors, the transition country set "consists of all transition countries after the breakup of the Soviet Union, as well as Turkey" (p. 7). This study measured and compared the agricultural productivity of the transition countries with the European countries. Their findings provide useful information for formulating policies to achieve higher growth in countries going through a transition. The data used to measure Malmquist TFP index consist of agricultural output and input quantities. Output variables include aggregate crop and livestock production indices. The five input variables are land, tractors, labor, fertilizer, and livestock. Results showed that the TFP disparity between the European and the transition countries decreased during the period of 1992-2002.

Coelli and Rao (2005a) examined agricultural output and productivity in 93 developed and developing countries for the period 1980 to 2000. They used DEA to calculate the Malmquist TFP index. Coelli and Rao used an output-oriented DEA approach because they made the assumption that farmers' goals in agriculture are to maximize output from the available inputs. In the output-oriented approach, the DEA method looks for the maximum increase in output while holding inputs constant. Coelli and Rao used crops and livestock production as the two output variables. The input series were land, tractors, labor, fertilizer, livestock, and irrigation. The result shows an annual average growth of 2.1% among the 93 countries. Efficiency contributed 0.9% to the TFP, and technical change contributed 1.2%. Fulginiti and Perrin (1997); Suhariyanto, Lusigi, and Thirtle (2001); and Trueblood and Coggins (2003) found that developed and developing countries' TFP disparity increased during the period 1961-1985. Following those studies, Coelli and Rao (2005) noticed a reversal of the TFP disparity and believed that the reversal continued between 1980 and 2000 as a result of decreasing technical disparity between developed and developing countries (technical convergence).

CHAPTER 3. DATA SOURCES AND METHODOLOGY

3.1. Data For Agricultural Output Production And Malmquist Productivity

This research first estimates the effect of agricultural productivity and labor, capital, animal, fertilizer, and land inputs on agricultural output. Data are taken from the FAO (2008).The bulk of the country-level data for these variables are from the period of 1976 to 2004. Data are from 64 different countries, including both developing and developed countries. The data description for each variable is given below.

Land: Land is measured as the land used for arable and permanent crops (1000 Ha).

Labor: Labor is measured as the economically active population involved in agriculture. These numbers are in units of 1000 and include both men and women.

Fertilizer: Consumption data are for nitrogen, potash, and phosphorus use (in tons) for each year and country. Following Trueblood (2003), the three series are added together to get the total amount of fertilizer used annually in each country.

Physical Capital: Physical capital is proxied by the total number of agricultural tractors that are in use in each country.

Livestock: Livestock includes animals raised either for meat and dairy production or for breeding purposes. Livestock are counted individually with the exception of poultry, birds, and rabbits, which are counted in groups of 1000. After collecting individual data by species, total livestock is calculated by a weighted aggregation of different animals. The weights are mules (1), horses (1), sheep (0.1), pigs (0.2), buffalo (1), goats (0.1), cattle (1), and poultry (0.01). These weights are the same as those in Hayami and Ruttan (1970) and Trueblood (1996).

Agricultural Output: The FAO (2009) defines agricultural output indices as "relative levels of the aggregate volume of agricultural production for each year in comparison with the base period 1999 to 2001" (para. 1). The total sum of the price-weighted agricultural products gives the output index numbers. Quantities used as seed and feed, which are price weighted, are subtracted from the agricultural commodities before the output indices are calculated. Country indices are calculated by the Laspeyres formula. First, the average international product prices of the period 1999-2001 are used to weight the quantity of production of each agricultural commodity for each year. Second, all the weighted production quantities of each commodity are added for each year. Then, the total weighted production quantities are divided by the average sum of the total weighted production quantities from the base period, 1999-2001. In order to avoid using exchange rates for computing the total production for different countries, "international commodity prices" are used. Comparing productivity across nations is much easier and more accurate when using "international commodity prices" instead of exchange rates (FAO, 2009).

3.2. Data For Agricultural Exports

This research also estimates the effect of openness, real gross domestic product per capita (CGDP), population and agricultural outputs on agricultural exports. Data for population, openness, and CGDP are from Heston, Summers, and Aten (2006). The data for the value of exports are collected from United Nations Commodity Trade Statistics Database (UN COMTRADE, 2008). The data description for each variable is given below.

Agricultural Exports: The Standard International Trade Classification (SITC), Revision 3, is used to classify exports under Broad Economic Categories (BEC). Agricultural exports are calculated as the sum of BEC 111 and BEC 121: BEC 111 (Food and Beverage (Primary) for Industry) and BEC 121 (Food and Beverage (Processed) for Industry). Exports are thus defined by agricultural products used as intermediate inputs in the importing countries rather than products satisfying final consumer demand. Exchange rates are used to normalize the value of exports into U.S. dollars. The exchange rates, which are given by different respective countries, are used to change the values of all agricultural products into U.S. dollars (United Nations Statistics Division [UNSD], 2009).

Openness: Openness (OPENC) is defined as the sum of exports and imports divided by GDP. Heston, Summers, and Aten (2002) define this ratio as "a country's total trade as a percentage of GDP" (p. 10).

CGDP: Heston et al. (2002) say that CGDP is found "from an aggregation using price parities and domestic currency expenditures for consumption, investment, and government using August 2001 as a base" (p. 3).

3.3. Conceptual And Econometric Model For Agricultural Output And Agricultural Exports

The primary focus of this research is to investigate the effects of agricultural productivity on agricultural exports. Impacts of productivity on exports are measured in two steps. In step one, agricultural output is estimated using a Cobb-Douglas production function as follows:

$$(1)\ \ln(\text{Output}_{ct}) = \beta_0 + \beta_1\ln(\text{Tractor}_{ct}) + \beta_2\ln(\text{Fertilizer}_{ct}) + \beta_3\ln(\text{Animal}_{ct}) + \beta_4\ln(\text{Land}_{ct}) + \beta_5\ln(\text{Labor}_{ct}) + \beta_6\text{CumTFP}_{ct} + \epsilon_{ct}.$$

Parameters $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5,$ and β_6 are parameters to be estimated. The last term is the error term. Cumulative TFP is used, which accumulates the year-to-year changes to provide a stock measure of total factor productivity instead of the year-to-year changes resulting from the DEA Malmquist measures.

From the Cobb-Douglas production function, the effects of the fitted or predicted agricultural output (from equation 1) on agricultural exports are determined in the second step as follows:

$$(2)\ \ln(\text{agricultural exports}_{ct}) = \alpha_0 + \alpha_1\ln(\text{exports}_{c(t-1)}) + \alpha_2\ln(\text{fitted\_output}_{ct}) + \alpha_3\ln(\text{cgdp}_{ct}) + \alpha_4\text{openness}_{ct} + \alpha_5\ln(\text{population}_{ct}) + \mu_{ct}.$$

Equation 1 allows for agricultural productivity differences among countries to explain the variations in agricultural output. Agricultural output is hypothesized to increase with increases in agricultural productivity. If the country's agricultural productivity increases relative to other countries, output relative to other countries is expected to increase accordingly. Countries with higher agricultural productivity attain a comparative advantage (Ricardo Effect) in the production of agricultural output. The comparative advantage gained in agricultural production is passed on to the primary and processed agricultural sectors (Gopinath & Carver 2002). If there is relatively more agricultural output production, there will be enough agricultural output to satisfy the domestic markets and still have excess supplies of primary and processed agricultural commodities for exports. Figure 3 shows the technology effect on a country's export of commodities.

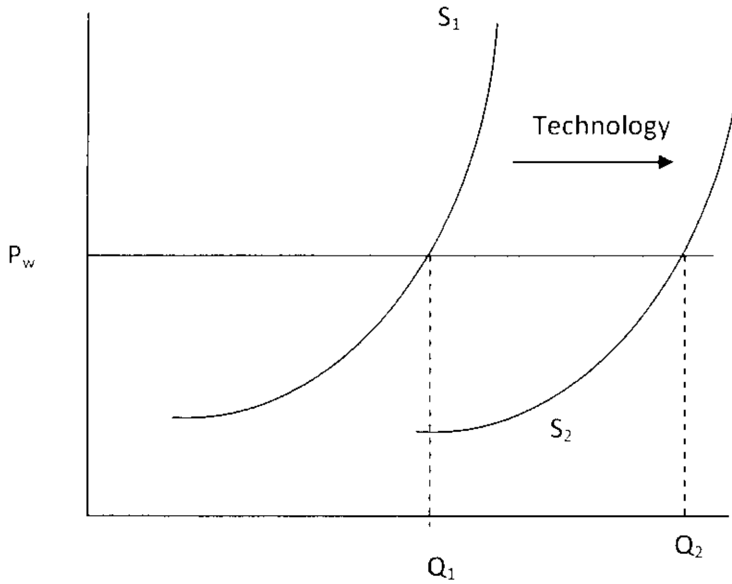


Figure 3. The Shift of the Supply Curve Due to Technology.

As seen from Figure 3, at the world price (P_w), an outward shift from S_1 to S_2, leads to greater potential exports. Hence, a country which was previously exporting Q_1 can increase its exports to Q_2. Therefore, technological improvements in a country may increase exports of agricultural commodities via their effects on agricultural output. The increase in exports due to cumulative TFP can be shown by multiplying the elasticity of cumulative TFP in equation 1 times the elasticity estimate of fitted agricultural output in equation 2 as follows:

(3) $$\beta_6 * \alpha_2 = \partial \text{exports} / \partial \text{cumTFP} \ .$$

Following Athukorala and Sen (1998), this research hypothesizes that openness, population, and CGDP affect agricultural exports. When export barriers are reduced, producers have access to more markets where they can sell their products. The lagged variable of exports shows that present exports of primary and processed agricultural commodities are affected by past exports.

Fitted agricultural output is used as an instrument for equation 2 because of the endogeneity of output. There might be variables which affect both agricultural output and agricultural exports. There might be relevant variables missing from the agricultural export equation. This will cause fitted agricultural output to be correlated with the error terms of the export equation. If the error terms of the exports equation are correlated with the fitted agricultural output, the estimates will be biased. To solve this potential problem of endogeneity, the approach of Frankel and Romer (1999), who solved the endogeneity problem between agricultural income and trade, is used. For this research, fitted agricultural output is used as an instrument first. An instrument should be correlated with the dependent variable of interest, not the error terms, so that the regression does not give biased, inaccurate results. It is assumed in this study that fitted agricultural output is correlated with agricultural exports but uncorrelated with the errors of the agricultural export equation.

There might be a correlation between the explanatory variables and the country-specific unobserved effects. To control for this correlation, a one-way fixed-effects model can be used. The fixed-effects model captures the differences in the dependent variable due to the unobserved effects. For example, dissimilarities among different countries may account for productivity differences. Instead of trying to find all the possible exogenous variables that can explain the difference, a one-way fixed-effects model is used.

Output (equation 1) and agricultural exports (equation 2) are estimated using the fixed-effects model, and the general representation is as follows:

$$(4) \qquad y_{it} = \sum_{k=1}^{K} x_{itk}\beta_k + u_{it} \ ,$$

where (y) is the endogenous variable and (x) are the exogenous variables, i=country, t= time, k= number of exogenous variables, and $u_{it} = \gamma_i + \varepsilon_{it}$. Nonrandom parameters to be estimated are " γ_i". Since including both the intercept and the "γ_i" induces a redundancy, nonrandom or country-specific dummy variables to be estimated are "γ_i-1". (SAS, 2009a).

3.4. Distance Function Measure Of Productivity Change

To determine the output-based Malmquist TFP index, Färe et al. (1994) considered a production technology, S^t, that transformed the $x \in R^N$ vector of inputs into the corresponding $y \in R^m$ vector of outputs for each time period, t=1,……T, as follows:

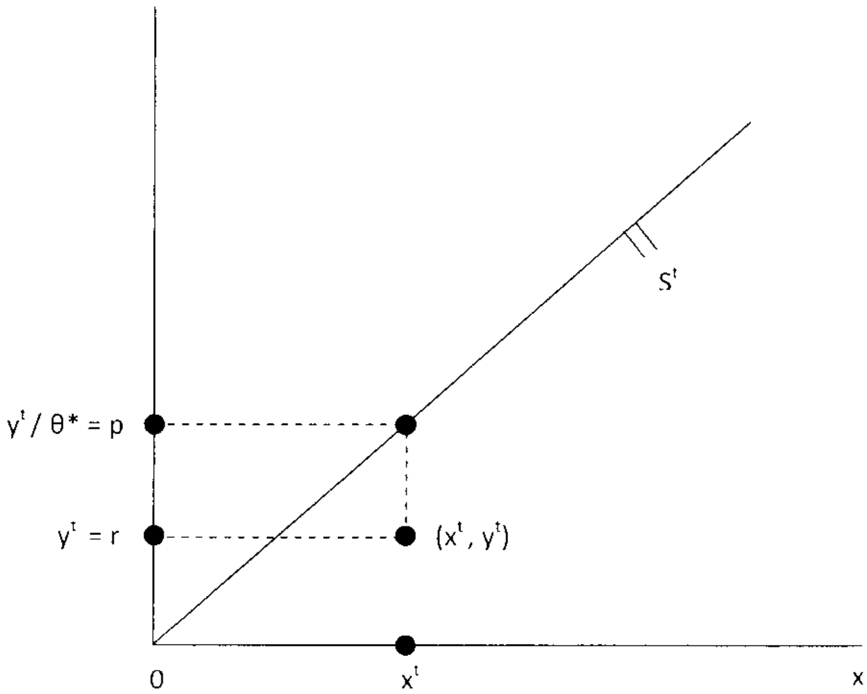
$$(5) \qquad S^t = \{(x,y) : x \text{ can produce } y \text{ at time } t\} .$$

Färe (1988) described the output distance function at time t as follows:

$$(6) \qquad D_0^t(x^t, y^t) = \inf\left\{\theta : \left(x^t, \frac{y^t}{\theta}\right) \in S^t\right\}$$

$$= (\sup\{\theta : (x, \theta\, y) \in S^t\})^{-1} .$$

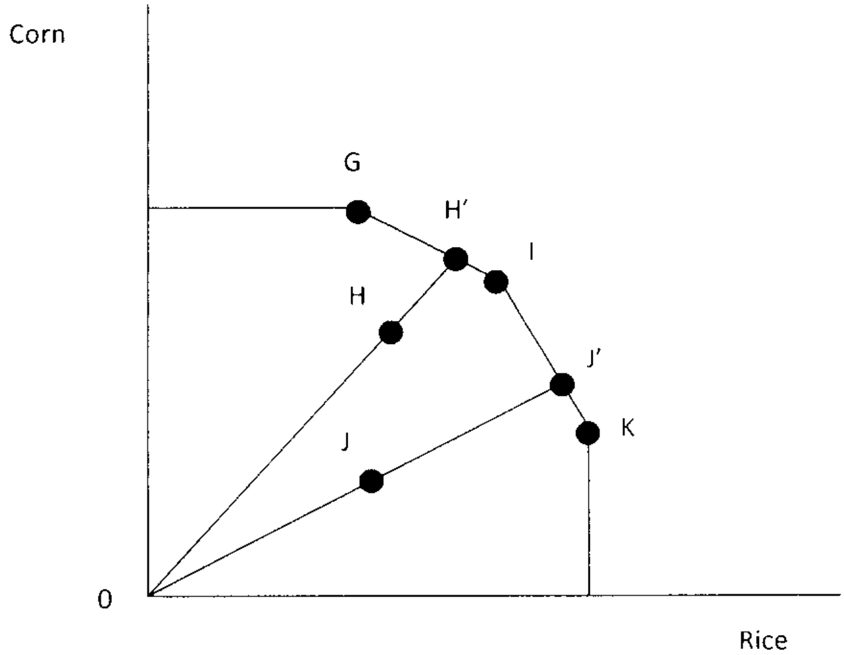
According to Färe et al. (1994), the output distance function is described as "the reciprocal of the maximum proportional expansion of the y vector of outputs given the x vector of inputs" (p. 69). Equation 5 describes the technology that transforms the x vector of inputs into the y vector of outputs. The production technology, S^t, is a production set on which the distance function, $D_0^t(x^t, y^t)$, is equal to 1 if the netput vector (x, y) lies on the production frontier. If the netput vector (x, y) lies within the boundary of S^t, the distance function will be less than 1. The output technical efficiency measured by Farrell (1957) is the reciprocal of the distance function described by Färe (1988) in equation 6 as how far the inefficient firm or country is from the technology frontier. The concept of the distance function described by Färe et al. (1994) is shown in Figure 4.



Adapted from Färe, Grosskopf, Norris, and Zhang (1994).

Figure 4. Distance Function for the Netput Vector (x^t, y^t).

The distance function for the netput vector (x^t, y^t) is 0r/0p, which is equal to θ. The distance function for (x^t, y^t) is less than 1 because the netput vector lies inside the boundary of the production frontier S^t. The technical efficiency score according to Farrell (1957) is given by 0p/0r, which is equal to 1/θ. The principle of the distance function can be applied to multiple outputs for many firms or countries. The production technology frontier for five countries and two inputs according to Coelli and Rao (2005) is illustrated in Figure 5.



Adapted from Coelli, Rao, O'Donnell, and Battese (2005b).
Figure 5. The Distance Function for a Multiple Production Function.

The distance functions for countries G, I, and K are equal to 1 because they all lie on the boundary of the production technology. For countries H and J, the distance function is less than 1 because they lie inside the boundary of the frontier. According to Farrell (1957), countries or firms can only lie on the boundary if their production is technically efficient. Therefore, countries G, I, and K are technically efficient countries, whereas H and J are inefficient.

Following Lambert and Parker (1998), given there is a set of K observations (total number countries) in time t, the output distance function for each nation (k) which produces output (y^k) from its given input set (x^k) in time period t can be computed by the solution of the linear programming problem presented as follows:

$$(7) \qquad (D_0^k(x^k, y^k))^{-1} = \text{Max } \theta$$

$$\text{s.t. } \theta y^k \leq \sum_{i=1}^{K} z_i y^i$$

$$\sum_{i=1}^{K} z_i x^i \leq x^k$$

$$z_i, \theta \geq 0 \ .$$

After solving the linear programming problem in equation 7, the efficiency of each country (k) relative to the production frontier is measured. Scalar θ provides information on the technical efficiency of each country. The concept of peers and technical efficiency score is shown in Figure 5. The peers of the inefficient country define the part of the production frontier against which the inefficient country's technical efficiency (TE) is measured relative to the boundary of the frontier. For example, the peers of country H are G and I. G and I define the production frontier for H. The inefficiency of country H is measured relative to the production frontier defined by countries G and I.

3.5. Decomposition Of The Malmquist Productivity Index

According to Färe et al. (1994), instead of calculating Malmquist TFP index in either "t" or "t+1" technology, the geometric mean of two Malmquist TFP indices during the two periods is calculated by equation 8 as follows:

$$(8) \qquad m_o(x^{t+1}, y^{t+1}, x^t, y^t)$$

$$= \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} .$$

The reference technology for the first term in the bracket is "t," and the reference technology for the second term is "t+1." Productivity progression from period "t" to "t+1" is indicated by an Malmquist TFP index greater than one, and productivity regression is indicated by an Malmquist TFP index less than one. According to Färe et al. (1994), an equivalent way of writing equation 8 for Malmquist TFP index is

$$(9) \qquad m_0(x^{t+1}, y^{t+1}, x^t, y^t)$$

$$= \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} .$$

The first ratio outside the bracket is the country's efficiency change component. According to Färe et al. (1994), efficiency change shows "the change in relative efficiency (the change in how far observed production is from maximum potential production) between years t and t+1" (p. 71). The ratios inside the brackets measure "technical change," which is the geometric mean of the shift in technology for time periods t and t+1 at inputs x^t and x^{t+1}. The ratios measure the shift in the production frontier due to the technical change taking place in a country.

Following Lambert and Parker (1998), the output distance for the production of a country (k) in time t with the "t+1" frontier is computed by the solution of the linear programming program as follows:

$$(10) \quad (D_0^{t+1}(x^t, y^t))^{-1} = \text{Max } \theta$$

$$\text{s.t.} \quad \theta y^t \leq \sum_{i=1}^{K} z_i y^{i,\ t+1}$$

$$\sum_{i=1}^{K} z_i x^{i,\ t+1} \leq x^t$$

$$z_i, \theta \geq 0 \ .$$

The solution to the output distance program $(D_0^t(x^{t+1}, y^{t+1}))^{-1}$ is found by reversing the roles of t and t+1 in equation 10.

The component distance functions of the Malmquist TFP index will be calculated for each of 64 countries during the period of 1976-2004. The changes in Malmquist TFP index will be attributed either to changes in the technical efficiency of the individual countries or to shifts in the production frontier that indicate technical change in world production (Lambert & Parker, 1998).

CHAPTER 4. RESULTS

4.1. Introduction

The results portion will initially present a summary of the Malmquist TFP index calculations for all 64 countries. Then, data from the agricultural output and agricultural export equations are evaluated using panel unit root tests. Next, the Hausman Test, which is modified for the two-step process, is conducted to examine if the model is a fixed-effects or random-effects model. The Hausman test is, then, used on the agricultural output equation, and finds that the fixed-effects model is appropriate. After including country-specific dummy variables in the output equation, the Hausman test is also conducted on the agricultural export equation, which contains the fitted agricultural output from the first step. The fixed-effects model is also proven to be appropriate for the export equation, and country-specific dummy variables are included in the export equation. After performing the Hausman tests, the autocorrelation and heteroskedasticity tests are conducted for the two-step process.

The autocorrelation and heteroskedasticity tests are modified for the two-step process. Respectively, both Godfrey and White tests are used to check for autocorrelation and heteroskedasticity in the agricultural output equation. Heteroskedasticity and autocorrelation are, in fact, found in the agricultural output equation; therefore, autocorrelation and heteroskedasticity are corrected using the heteroskedasticity-consistent covariance matrix estimation (HCCME) to get unbiased results. Autocorrelation and heteroskedasticity are then checked in the agricultural export equation, which contains the fitted agricultural output from the first step described in equation 1. Since autocorrelation and heteroskedasticity are found in the agricultural export equation using the Godfrey and White tests, corrections for autocorrelation and heteroskedasticity are made using HCCME to get unbiased results. Finally, regression results from the two-step process are presented, showing that productivity does affect exports.

4.2. Results For Efficiency Change, Technical Change, And Malmquist TFP Index

A list of the 17 countries with the highest average efficiency and technical change changes is presented in Appendix Table A-1. The top 15 countries with the highest average efficiency change (except Norway and Hong Kong) are developing countries: China, El Salvador, Jordan, Nicaragua, Qatar, Sri Lanka, Trinidad and Tobago, Malaysia, Jamaica, Honduras, Egypt, Costa Rica, Guatemala, Brazil, and Morocco. Norway has the highest average efficiency growth of .21% for the period 1976-2006.

The top 16 countries with the highest technical change (except Bolivia) are developed countries: Canada, Austria, United States, Denmark, Finland, Australia, France, Ireland, Italy, Hungary, Germany, United Kingdom, Sweden, New Zealand, Spain, and Israel). At 5%, Bolivia has the highest technical change. The United States and Canada have the fourth and second highest technical change, respectively. Canada achieved 4%, and the United States achieved a 3% growth due to technical change. These countries produce or adopt new technologies which expand their production possibility curves outward.

Appendix Table A-2 shows the mean Malmquist TFP indices for all 64 countries. Jordon has the highest Malmquist TFP index of 6.4%, and the Republic of South Korea has the lowest Malmquist TFP index of -8.61%.

Average efficiency change, technical change, and Malmquist TFP index for six regions of the world are presented in Table 1.

Table 1. Efficiency Change, Technical Change, and Malmquist TFP Index for Regions.

Region	Efficiency Change	Technical Change	Malmquist
Middle East	1.05	.93	.92
North Africa	1.08	.96	1.02
Europe	1.01	1.01	1.01
North America	1.01	1.01	1.02
Central America and Caribbean	1.08	.97	1.02
Australia and Oceania	.99	1.02	1.01
Asia	1.05	.95	.98
South America	1.03	.98	1.01

Countries in Central America and Caribbean have the highest Malmquist TFP growth rate of 2.5%, which is attributed to an 8.87% growth in efficiency change and a 2.98% negative growth in technical change. The highest efficiency change is observed in Central America and the Caribbean, and the lowest efficiency change is observed in Australia and Oceania. The highest technical change is observed in Australia and Oceania, and the lowest technical change is observed in the Middle East. The Middle East has the lowest Malmquist TFP change, with growth regressing 7.01% due to a 5.49% growth in efficiency change and negative growth rate of 6.19% in technical change. Asia also has a negative growth rate of 1.31% in Malmquist TFP during this period. North America attains a Malmquist TFP growth of 2.12% attributed to a 1.06% growth in efficiency change and a 1.64% growth in technical change.

4.3. Tests For Unit Roots, Hausman Test, Autocorrelation, And Heteroskedasticity

Variables in the unbalanced panel are tested for unit roots to determine whether the variables are stationary (Table 2).

Table 2. Results for Unit Roots.

Variable	Without Trend	With Trend	Results
Log of Agricultural Output	-2.35	-2.86	Stationary
Log of Animal	-2.81	-2.41	Stationary
Log of CGDP	-14.14	-9.58	Stationary
Cumulative TFP	-2.17	-5.88	Stationary
Log of Fertilizer	-2.50	-3.70	Stationary
Log of Labor	-2.04	-2.98	Stationary
Log of Land	-2.13	-2.80	Stationary
Openness	-3.52	-2.62	Stationary
Log of Population	-5.62	-4.45	Stationary
Log of Tractor	-6.93	-2.89	Stationary
Log of Agricultural Exports	-2.584	-3.62	Stationary

For unit roots, the critical value for without trend is -1.67 at the 5% significance level, and for with trend, the critical value is -2.34 at the 5% significance level (Im, Pesaran, Shin. 2003). The null hypothesis is that there is a unit root (nonstationary), and the alternate hypothesis is that there is no unit root (stationary). All the absolute values for the without trend unit root test are more than 1.67; therefore, all variables are stationary. All the absolute values for the with trend unit root test are more than 2.34; therefore, all variables are stationary.

The Hausman test is conducted to examine if the model is a fixed-effects or random-effects model (SAS, 2009b). The Hausman test is modified for the two-step process of the agricultural output and the agricultural export equations. First, the Hausman test for the agricultural output equation is conducted. The result of the Hausman test for the agricultural output equation is presented in Table 3.

Table 3. Results for the Hausman Test for Agricultural Outputs and Exports.

Equation	Degrees of Freedom	M Value	P Value
Agricultural Output	6	46.99	0.0001
Agricultural Exports	4	8.73	0.0682

The P-value is less than .05 for the agricultural output equation. Therefore, the null hypothesis of the random-effects model being appropriate is rejected. After it is found that the fixed-effects model is appropriate for the agricultural output equation, country-specific dummy variables are included in the output equation, and the Hausman test is conducted for the agricultural export equation using the fitted agricultural output from the first step. The P-value is less than the .10 significance level for the agricultural export equation. Therefore, the null hypothesis of the random-effects model being appropriate is rejected. It is found that the agricultural export equation also needs a fixed-effects model (Table 3). Country-specific dummy variables are included in the agricultural export equation.

After putting the fixed-effects models in the agricultural output and agricultural export equations, the two equations are tested for heteroskedasticity and autocorrelation. The autocorrelation and heteroskedasticity tests are modified for the two-step process. First, the agricultural output equation is tested for heteroskedasticity and autocorrelation using White and Godfrey serial correlation tests, respectively (SAS, 2009c; SAS, 2009d). The results for the heteroskedasticity and autocorrelation tests of the agricultural output equation are presented in Tables 4 and 5, respectively.

Table 4. Results of Test for Heteroskedasticity.

	Statistic	Degrees of Freedom	P-Value	Result
Agricultural Output	1200	616	.0001	Heteroskedasticity
Agricultural Exports	1213	415	.0001	Heteroskedasticity

Table 5. Results of Test for Autocorrelation.

Equation	Alternate	LM	P-Value	Result
Output	1	90.93	.0001	Autocorrelation
	2	104.1	.0001	Autocorrelation
	3	105.3	.0001	Autocorrelation
Exports	1	640.3	.0001	Autocorrelation
	2	675.2	.0001	Autocorrelation
	3	675.4	.0001	Autocorrelation

Since the P-value is less than .05 for the agricultural output, the null hypothesis of no heteroskedasticity being present is rejected (Table 4). Similarly, the null hypothesis of no autocorrelation being present is rejected for the agricultural output because the P-value is less than .05 (Table 5). Since heteroskedasticity and autocorrelation are found using White and Godrey serial correlation tests, respectively, autocorrelation and heteroskedasticity are corrected using HCCME to get unbiased results (Chvosta & Erdman, 2007).

After correcting the problem of heteroskedasticity and autocorrelation in the agricultural output equation, the agricultural export equation is tested for heteroskedasticity and correlation using the fitted values of agricultural output from the first step. Again, White and Godrey tests for heteroskedasticity and autocorrelation, respectively, are conducted. Since the P-value is less than .05, the null hypothesis of no heteroskedasticity is rejected for the agricultural export equation (Table 4). The null hypothesis of no autocorrelation being present is rejected because the P-value is smaller than .05 (Table 5). Corrections are made for heteroskedasticity and autocorrelation for the agricultural export equation using HCCME to get unbiased results.

4.4. Results For Agricultural Output And Agricultural Exports

The result for the agricultural output equation is presented in Table 6.

Table 6. Result of the Regression Result for Agricultural Output.

Variables	Parameter	T-Value	P-Value
Constant	-7.36 (2.24)	-3.38	.0010
Log of Tractors	.1749 (.0423)	4.13	.0001
Log of Fertilizer	.1942 (.0257)	7.56	.0001
Log of Animals	.0123 (.00039)	3.11	.0019
Cumulative TFP	.7986 (.1159)	6.89	.0001
Log of Size of Land	.2831 (.0395)	7.17	.0001
Log of Labor	.1559 (.0619)	2.52	.0118

The adjusted R-square is .99. Coefficients of tractors, fertilizers, animals, land, cumulative TFP, and labor are positive and significant. Increases in each dependent variable cause various increase in output. For example, a 1% increase in tractors would cause a .17% increases in output. The same percentage increase in fertilizer, animals, land, and labor would cause increases of .19%, .01%, .28%, and .15%, respectively. If cumulative TFP increases by 1 unit, the agricultural output increases by .79%.

Countries with higher cumulative TFP are hypothesized to have a higher agricultural output. The output shares, export shares, and the weighted average cumulative TFPs for the eight regions can be calculated for the year 2002 from the data that are used to conduct the regressions. The shares and TFP are reported in Table 7.

Table 7. Output Shares, Export Shares, and Weighted Average Cumulative TFP for 2002.

Regions	Output Shares	Export Shares	Weighted Average Cum TFP
Middle East	.005	.005	.17
North Africa	.03	.008	.17
Europe	.24	.47	.73
North America	.22	.22	1.20
Central America and Caribbean	.18	.04	.13
Australia and Oceania	.02	.05	1.22
Asia	.13	.07	.15
South America	.14	.10	.37

It seems that both North America and Europe have higher output shares of .22 and .24, respectively, than the other regions of the world. Except for Australia and Oceania, the TFPs for North America and Europe are higher than those of the other regions. Therefore, it seems that North America and Europe may have higher agricultural output shares because of their relatively higher TFPs.

The results for the agricultural exports equation are presented in Table 8 below. The adjusted R-square is .97. Coefficients of CGDP, fitted agricultural output, population, openness, and lags of exports of commodities are significant and positive. If the population increases by 1%, exports increase by .62%. The same 1% increase in CGDP, lag of commodities, and fitted agricultural output will increase exports by .50%, .19%, and .37%, respectively. The lag of exports is positive and significant, showing that producers learn from their past knowledge and experience.

A possible explanation for the positive CGDP and population is that, when CGDP and population increase, people will demand more goods. In order to meet the increased demand for goods, it may be necessary to increase imports, and in order to cover the cost of increased imports, it may be necessary to generate more revenue by increasing exports. If that is the case, then an agricultural export increase may simply be an effect of a total export increase.

Table 8. Results of the Regression for the Exports of Primary and Processed Agricultural Commodities.

Variables	Estimate	T-Value	P-Value
Constant	-0.76 (1.13)	-0.67	.5
Log of Fitted Agricultural Output	.37 (.04)	8.36	.0001
Log of Population	.62 (.12)	4.83	.0001
Log of CGDP	.50 (.03)	12.83	.0001
Openness	.001 (.0006)	1.89	.05
Log of Lag of Export of Commodities	.19 (.03)	6.22	.0001

The elasticity of cumulative TFP in equation 1 and the elasticity of the fitted agricultural output in equation 2 are both significant and positive, which shows that TFP has a positive and significant effect on the exports of primary and processed commodities via TFP's effect on the agricultural output. The impact of the change of TFP on exports can be computed from equation 3. If cumulative TFP increases by 1 unit, the agricultural exports increase by .29%.

The results indicate that countries with higher TFPs should have higher export levels of primary and processed commodities. Larger outputs due to higher agricultural productivity result in more commodities to satisfy domestic consumption and excess agricultural outputs for the exports of primary and processed commodities. Therefore, the excess agricultural output (due to high cumulative TFP) shifts the export supply curve of primary and processed commodities outward (Figure 3), which increases the quantity of primary and processed agricultural commodities exported in the world market.

The comparative advantage gained from the relatively higher TFP of developed nations may translate to the higher export shares of primary and processed commodities. From Table 7, it seems that North America and Europe have a higher output share and export share than other regions. Except for Australia and Oceania (1.22), North America (1.20) and Europe (.73) also have higher TFPs than the other regions. Therefore, the higher TFPs of Europe and North America may have increased export shares via the TFP's effect on the output shares. Consequently, Europe (.47) and North America (.22) can export more agricultural commodities than other regions. From the regression results and from the information presented in Table 7, it seems that developed countries may have higher export shares of agricultural commodities because of their relatively higher cumulative TFPs. Developing countries in South America, Central America, the Caribbean, Asia, North Africa, and Asia may have a lower share of agricultural exports due to their relatively lower TFPs in comparison with the TFPs of Europe and North America.

4.5. Discussions

Ghazalian and Furtan (2007) and the United States Department of Agriculture (USDA, 2001) conclude that investing in research and development for agriculture increases productivity. Therefore, developing countries may be able to increase their agricultural exports if they invest in research and development for agriculture. Developing countries may not have enough resources to conduct research and development by themselves. There are many leading research institutions which are founded by developed nations. International Rice Research Institute (IRRI), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), and Consultative Group on International Agricultural Research (CGIAR) are examples of leading research institutions. Because of such institutions, developing countries may work with developed nations to research and develop new agricultural technology and methods that will boost productivity and, by extension, exports.

Most leading agriculture research institutions work with the national institutions of developing countries to develop better varieties of crops, which give better yields but also use less water, fertilizer, and other inputs. IRRI is an agricultural research and training organization with offices in more than 10 countries. IRRI was formed by the Ford and Rockefeller Foundations with assistance from the government of the Republic of the Philippines. IRRI started conducting research in 1960. It develops new varieties of rice crops. According to IRRI, some of its goals are to find a sustainable method to produce rice, to have a less negative impact on the environment, and to be able to adapt to the climatic changes. These goals tie in with improving the economic conditions, nutrition, and health of both farmers and consumers in developing countries. IRRI works with other national agricultural research institutions, local farmers, and other major institutions to perform research on rice production. IRRI focuses on increasing rice yields with less consumption of water, labor, and chemical fertilizer (IRRI, 2007).

CIMMYT is one of the 15 non-profit, research and training institutions affiliated with the CGIAR. CIMMYT's goals are to reduce hunger by increasing the availability of food and to increase the profit and productivity of farmers in developing countries while making sure that agricultural production does not damage the environment. CIMMYT tries to achieve these goals by investing in scientific research (mainly in maize and wheat), and also by forming partnerships and sharing knowledge with the leading research institutions of developing countries. CIMMYT's research goal is to focus on cooperating with host nations to deliver a range of products that impact countries which depend on "wheat-based" or "maize-based" farming for their income. The new technologies that have been discovered by CIMMYT include genetically enhanced seeds which give a better yield and at the same time do not damage the environment (CIMMYT, 2009b). Some of the products are "stress-tolerant maize, rust-resistant wheat, resource conservation technologies for maize and wheat cropping systems, and bio-fortified maize for improved nutritional values and health" (CIMMYT, 2009a).

CGIAR's goal is to decrease food instability and to increase income by investing in research and development for the fields of agriculture, forestry, fisheries, policy, and the environment. CGIAR was formed in 1971 and works with both governmental and private institutions to promote sustainable agricultural growth. Its members include 21 developing countries and 26 developed nations. At the present time, there are more than 8000 scientists and staff who are conducting research in more than 100 countries. All of these organizations are dedicated to creating self-sustaining agricultural growth that may lead to expanded agricultural exports, greater purchasing power parity, and a greater market share for developing countries (CGIAR, 2007-2008).

The results show that, on average, technology leads to export increases. However, if the effects of trade barriers (tariffs and quotas, export subsidies) on exports are considered, the effect of TFP on exports may be relatively lower. Countries may have lower exports despite having relatively higher TFPs due to export subsidies as well as tariffs and quotas.

Export subsidies are defined as the "direct or indirect payments" made to producers of a country to encourage or increase the exports of that country. These subsidies can be given in the form of direct payments, lower taxes, low-interest loans, etc. These subsidies encourage producers to sell their products on the world market. The increase in agricultural products causes an oversupply which reduces the world price. The reduction in world prices harms the domestic producers of the developing countries because they cannot provide the same level of agriculture protection as the developed nations. Richer nations provide export subsidies because developed countries have a high level of support in the agricultural sector, resulting in overproduction. To solve the problem of overproduction, imports are discouraged, and producers are encouraged to export with subsidies (Koo & Kennedy, 2005).

Developing nations may not be able to export their products by increasing their TFP level if they cannot give the same amount of export subsidies to their producers as is provided to producers in the developed world. Some countries which have a low level of TFP will still be able to export more due to the export subsidies given to them. According to Young, Abbott, and Leetma (2001), the percentage of total export subsidies given to Europe was 89.4%, and for the United States, it was 1.5%. For Switzerland, Norway, and the rest of the world, it was 5.1%, 1.3% and 2.7%, respectively.

The other reason countries cannot export more agricultural commodities, even if they have a higher TFP, is because of the tariffs and quotas placed on agricultural commodities. Tariffs placed on exported goods by importing nations can significantly raise the price of these commodities, and whatever advantage a country may have gained in technology, it will not be able to increase the exports. Even if a country can produce a large amount of commodities at a relatively lower cost, countries cannot export if quota restrictions are imposed by importing nations. For example, Mexico can grow a large amount of oranges at a relatively lower cost than the United States, but the United States can place quota restrictions on the amount of Mexican oranges that come into the United States. Therefore, even if Mexico has an increase in TFP, Mexico will not be able to increase its exports because of the trade barriers.

The ongoing Doha Round is focusing on reducing the tariffs and quotas that still exist between developing and developed countries in order to allow real gains in productivity among developing nations to translate into equivalent gains in exports and market share. In general, it is believed that softening protectionist policies will open opportunities for best-use/best-practice, lower operating costs and efficiency losses throughout the agricultural product market.

CHAPTER 5. SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Chapter 5 concludes the study with a summary of the study scope and the results.

5.1. Thesis Summary

The main point of this research was to estimate the effect of agricultural productivity on exports. This study utilized unbalanced panel data spanning almost three decades (1976-2004) from 64 countries. A DEA was used to find the Malmquist TFP index for agricultural productivity. The two-stage estimation procedure was used to determine productivity impacts on exports. Agricultural output was estimated first with cumulative productivity, land, labor, capital, animal, and fertilizer as the explanatory variables. Then, agricultural export was estimated second with population, trade openness, CGDP, and fitted agricultural output as the explanatory variables.

Panel unit root tests, developed by Im et al. (2003), were conducted to determine whether the individual data series were stationary. The Hausman test, which was modified for the two-step process, was used to determine whether the fixed-effects or the random-effects model was appropriate for this study. First, the Hausman test was conducted for the agricultural output equation. Then, the Hausman test was conducted for the export equation. After performing the Hausman tests, the autocorrelation and heteroskedasticity tests were conducted for the two-step process.

The autocorrelation and heteroskedasticity tests were modified for the two-step process as well. First, the autocorrelation and heteroskedasticity tests were performed on the agricultural output equation. Then, the autocorrelation and heteroskedasticity tests were conducted on the export equation.

5.2. Results

Results of the Im et al. (2003) procedures indicated that all variables are stationary. The Hausman tests showed that fixed-effect models are appropriate for both the agricultural output and export equations. Heteroskedasticity and autocorrelation were found in the agricultural output and export equations, and corrections were made for them using HCCMI. Coefficients of agricultural productivity, land, labor, capital, animals and fertilizers were positive and significant in the agricultural output equation. The increase in agricultural productivity, along with the factor endowments in land, labor, capital, animals, and fertilizers, increases agricultural output. Coefficients of lag of exports, fitted agricultural output, CGDP, openness, and population were positive and significant in the agricultural export equation.

Both the cumulative TFP in the agricultural output equation (first step) and fitted agricultural output in the agricultural export equation (second step) are positive and significant. Therefore, the cumulative TFP has a significant and positive impact on agricultural exports via TFP's effect on agricultural output. If the cumulative TFP increases by 1 unit, the agricultural exports increase by .29%.

Developed nations may be able to supply more exports because richer countries have relatively higher TFPs compared to developing countries. Consequently, developing nations may not be able to capture the benefits of agricultural exports. However, data from this study suggest that research and development may increase agricultural productivity. Therefore, developing countries may be able to increase their exports and, hence, get more benefits from exports by investing in research and development for agriculture.

One of the ways poorer nations can improve technology is by working with leading research institutions from developed nations. Even with significant technological-based efficiency and productivity improvements, a country may not be able to increase exports by increasing TFP if there are trade barriers like export subsidies, tariffs, and quotas. Therefore, trade policies are a vital factor in determining exports.

REFERENCES

Alcala, F., & Ciccone, A. (2004). Trade and productivity. *The Quarterly Journal of Economics, 119*(2), 613-646.

Arnade, C., & Vasavada, U. (1995). Causality between productivity and exports in agriculture: Evidence from Asia and Latin America. *Journal of Agricultural Economics, 46,* 174-186.

Athukorala, P., & Sen, K. (1998). Processed food exports from developing countries: Patterns and determinants. *Food Policy, 23,* 41-54.

Bernard, B. B., & Jensen, J. B. (1999). Exceptional exporter performance: Cause, effect or both? *Journal of International Economics, 47,* 1-25.

Centro Internacional de Mejoramiento de Maiz y Trigo. (2009a). *Flagship Products.* Retrieved December 12, 2008, from the CIMMYT web site: http://www.cimmyt.org/english/wpp/flagsh/index.cfm

Centro Internacional de Mejoramiento de Maiz y Trigo. (2009b). *Mission, vision, and strategic goals.* Retrieved December 12, 2008, from the CIMMYT web site: http://www.cimmyt.org/english/wps/about/index.htm

Chvosta, J., & Erdman, D. (2007). *Analyzing time series cross-sectional data with the panel procedure.* Retrieved October 15, 2008, from the SAS Web site: http://www2.sas.com/proceedings/forum2007/170-2007.pdf

Coelli, T. J., & Rao, D. S. P. (2005a). Total factor productivity growth in agriculture: A Malmquist index analysis of 93 Countries, 1980-2000. *Agricultural Economics, 32,* 115-134.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005b). Productivity and efficiency measurement concepts. *An Introduction to Efficiency and Productivity Analysis* (2th edition.). New York, NY: Springer Science+Business Media, Inc.

Consultative Group on International Agricultural Research. (2007-2008). *Who we are.* Retrieved December 12, 2008, from the CGIAR web site: http://www.cgiar.org/who/index.html

Delgado, M. A., Farinas, J. C., & Ruano, S. (2002). Firm productivity and export Markets: A non-parametric approach. *Journal of International Economics, 57*(1), 397-422.

Färe, R. (1988). *Fundamentals of production theory.* Berlin, Germany: Springer-Verlag.

Färe, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *The American Economic Review, 84*(1), 66-83.

Farrell, M. J. (1957). The measure of productive efficiency. *Journal of the Royal Statistical Society. Series A (General), 120*(3), 253-290.

Food and Agriculture Organization of the United Nations. (2004). *The state of agricultural commodity markets.* Retrieved August 15, 2008, from the FAO of the United Nations Web site: http://www.fao.org/docrep/007/y5419e/y5419e00.HTM

Food and Agriculture Organization of the United Nations. (2005). *The state of food and agriculture.* Retrieved August 15, 2008, from the FAO of the United Nations Web site:

http://www.fao.org/docrep/008/a0050e/a0050e00.htm

Food and Agriculture Organization of the United Nations. (2008). *FAO statistical database.* Retrieved August 15, 2008, from the FAO of the United Nations Web site:

http://faostat.fao.org/site/348/default.aspx

Food and Agriculture Organization of the United Nations. (2009). *Trade indices notes.* Retrieved January 11, 2009, from the United Nations Web site:

http://faostat.fao.org/site/612/default.aspx#ancor

Francisco, A., & Ciccone, A. (2004). Trade and productivity. *The Quarterly Journal of Economics, 119,* 612-645.

Frankel, J. A., & Romer, D. (1999). Does trade cause growth? *The American Economic Review, 89,* 379-399.

Fulginiti, L. E., & Perrin, R. K. (1997). LDC agriculture: Nonparametric Malmquist productivity indexes. *Journal of Development Economics, 53,* 373-390.

Ghazalian, P. L., & Furtan, W. H. (2007). The effect of innovation on agricultural and agri-food exports in OECD countries. *Journal of Agricultural and Resource Economics, 32*(3), 448-461.

Gopinath, M., & Kennedy, P. L. (2000). Agricultural trade and productivity growth: A state-level analysis. *American Journal of Agricultural Economics, 82,* 1215-1220.

Gopinath, M., & Carver, J. (2002). Total factor productivity and processed food trade: A cross country analysis. *Journal of Agricultural and Resource Economics, 27,* 539-553.

Griffin, R. W., & Pustay, M. W. (2005). International trade and investment theory. In *International business* (4th ed., pp. 120-151). Upper Saddle River, NJ: Pearson Education.

Harrigan, J. (1997). Technology, factor supplies, and international specialization: Estimating the Neoclassical model. *The American Economic Review, 87*(4), 475-494.

Hayami, Y., & Ruttan, V. W. (1970). Agricultural productivity differences among countries. *The American Economic Review, 60*(5), 895-911.

Heston, A., Summers, R., & Aten, B. (2002). *Data appendix for a space-time system of national accounts: Penn world table 6.1.* Retrieved August 15, 2008, from the Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania Web site: http://pwt.econ.upenn.edu/Documentation/append61.pdf

Heston, A., Summers, R., & Aten, B. (2006). *Penn world table version 6.2.* Retrieved August 15, 2008, from the Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania Web site: http://pwt.econ.upenn.edu/php_site/pwt62/pwt62_form.php

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115,* 53-74.

International Rice Research Institute. (2007). *IRRI's mission.* Retrieved Dec 12, 2008, from IRRI's web site: http://www.irri.org/about/mission.asp

Koo, W. W., & Kennedy, P. L. (2005). Nontariff trade barriers. In *International trade and agriculture* (pp. 128-131). Malden, MA: Blackwell Publishing.

Kunst, R. M., & Marin, D. (1989). On exports and productivity: A causal analysis. *Review of Economics and Statistics, 71*(4), 699-703.

Lambert, D. K., & Parker, E. (1998). Productivity in Chinese provincial agriculture. *Journal of Agricultural Economics, 49*(3), 378-392.

Lissitsa, A., Rungsuriyawiboon, S., & Parkhomenko, S. (2007). How far are the transition countries from the European standards of the European Union? *Eastern European Economics, 45*(3), 51-75.

Loecker, D. (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics, 73*(1), 69-98.

Ludena, C. E., & Hertel, T. W. (2005). *Effects of productivity growth in primary agriculture on processed food exports and the food processing sector: An historical analysis.* Retrieved August 15, 2008, from International Food and Agribusiness Association Web site: http://www.ifama.org/tamu/iama/conferences/2005Conference/Papers&Discussions/1117_Paper_Final.pdf

Miller, S. M., & Upadhyay, M. (2000). The effect of openness, trade, orientation, and human capital on total factor productivity. *Journal of Development Economics, 63*(2), 399-423.

Morley, B., & Morgan, W. (2008). Causality between exports, productivity and financial support in European Union agriculture. *Regional Studies, 42,* 189-198.

SAS. (2009a). Notation. Retrieved January 15, 2009, from the SAS Web site:

http://support.sas.com/documentation/cdl/en/etsug/60372/HTML/default/etsug_panel_sect024.htm

SAS. (2009b). *Hausman specification test.* Retrieved January 15, 2009, from the SAS Web site: http://support.sas.com/documentation/cdl/en/etsug/60372/HTML/default/etsug_model_sect050.htm

SAS. (2009c). *Testing for autocorrelation.* Retrieved January 15, 2009, from the SAS Web site: http://support.sas.com/documentation/cdl/en/etsug/60372/HTML/default/etsug_model_sect044.htm

SAS. (2009d). *A simple regression model with correction of heteroskedasticity.* Retrieved January 15, 2009, from the SAS Web site: http://support.sas.com/rnd/app/examples/ets/hetero/index.htm

Suhariyanto, K., Lusigi, A., & Thirtle, C. (2001). Productivity growth and convergence in Asian and African agriculture. In P. Lawrence & C. Thirtle (Eds.), *Asia and Africa in Comparative Economic Perspective* (pp.258-274). London: Palgrave.

Suranovic, S.M. (2004). *International trade theory and policy.* Retrieved December 11, 2008, from the International Economics Study Center Web site: http://internationalecon.com/Trade/Tch60/T60-3.php

Thompson, R. L. (2007). *Globalization and the benefits of trade.* Retrieved August 15, 2008 from the Federal Reserve Bank of Chicago Web site: http://www.chicagofed.org/publications/fedletter/cflmarch2007_236.pdf

Trefler, D. (1995). The case of the missing trade and other mysteries. *American Economic Review, 85*(5), 1029-1046.

Trueblood, M. A. (1996). Nonparametric estimates of intercountry agricultural efficiency and productivity. Ph.D. dissertation, University of Minnesota, St. Paul, MN.

Trueblood, M. A., & Coggins, J. (2003). *Intercountry Agricultural Efficiency and Productivity: A Malmquist Index Approach.* Retrieved August 15, 2008, from the Department of Applied Economics of University of Minnesota Web site: http://www.apec.umn.edu/faculty/jcoggins/documents/Malmquist.pdf

United Nations Commodity Trade Statistics Database. (2008). *UN Comtrade database.* Retrieved August 15, 2008, from the United Nations Commodity Trade Statistics Database Web site: http://unstats.un.org/unsd/comtrade

United Nations Statistics Division. (2009). *Detailed structure and explanatory notes.* Retrieved August 15, 2008, from the United Nations Statistics Division Web site: http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=10&Lg=1&Co=1

United States Department of Agriculture. (2001). *Agricultural research and development, agricultural productivity, and food security.* Retrieved August 15, 2008, from the United States Department of Agriculture Web site: http://ageconsearch.umn.edu/bitstream/33685/1/ai076510.pdf

Wagner, J. (2007). Exports and productivity: A survey of the evidence from the firm-level data. *The World Economy, 30,* 60-82.

Weyerbrock, S. (2001). The impact of agricultural productivity increases in the former Soviet Union and Eastern Europe on world agricultural markets. *Agricultural Economics, 26,* 237-251.

World Resource Institute. (2007). *GDP: Percent GDP from Agriculture.* Retrieved August 15, 2008, from the World Resource Institute Web site: http://earthtrends.wri.org/searchable_db/index.php?theme=5&variable_ID=214&action=select_countries

World Trade Organization. (n.d.). *Agriculture: Fairer markets for farmers.* Retrieved December 12, 2008, from the World Trade Organization Web Site: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm3_e.htm

World Trade Organization. (n.d.). *The GATT years: From Havana to Marrakesh.* Retrieved December 12, 2008, from the World Trade Organization Web Site: http://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm

World Trade Organization. (2008). *10 Benefits of the WTO trading system.* Retrieved August, 2008, from the WTO website: http://www.wto.org/english/res_e/doload_e/10b_e.pdf

Young, L.M., Abbott, P.C., & Leetma, S. (2001). *Export competition: Issues and options in the agricultural negotiations.* Retrieved August 15, 2008, from the Agecon Search Web site: http://ageconsearch.umn.edu/bitstream/14624/1/cp15.pdf

APPENDIX

Table A-1. List of 17 Countries with the Highest Average Efficiency and Technical Change.

Country	Efficiency Change	Country	Technical Change
Norway	1.219	Bolivia	1.054
China	1.139	Canada	1.042
El Salvador	1.126	Austria	1.035
Jordan	1.118	United States	1.034
Nicaragua	1.111	Denmark	1.029
Qatar	1.107	Finland	1.025
Sri Lanka	1.098	Australia	1.023
Trinidad	1.085	France	1.022
Malaysia	1.084	Ireland	1.020
Jamaica	1.084	Italy	1.020
Honduras	1.084	Hungary	1.020
Egypt	1.083	Germany	1.020
Hong Kong	1.079	United Kingdom	1.019
Costa Rica	1.066	Sweden	1.019
Guatemala	1.066	New Zealand	1.019
Brazil	1.064	Spain	1.018
Morocco	1.064	Israel	1.016

Table A-2. Mean Technical Efficiency Change, Technical Change, and Malmquist TFP Index.

Country	Efficiency	Technical	Malmquist TFP Index
Algeria	1.12	0.96	1.06
Argentina	0.99	0.98	0.97
Australia	0.99	1.02	1.02
Austria	1.00	1.04	1.04
Barbados	1.05	1.00	1.04
Bolivia	1.00	1.05	1.06
Brazil	1.06	0.99	1.03
Canada	1.00	1.04	1.04
Chile	1.04	0.97	0.99
China	1.14	0.93	1.02
ChinaHKSA	1.08	0.93	0.99
Colombia	1.05	0.97	1.00
Costa Rica	1.07	0.98	1.01
Cyprus	1.02	0.99	1.01
Denmark	1.01	1.03	1.04
Ecuador	1.03	0.97	0.99
Egypt	1.08	0.95	1.00
El Salvador	1.13	0.96	1.05
Ethiopia	1.00	1.01	1.01
Finland	0.99	1.03	1.01
France	1.01	1.02	1.02
Germany	1.01	1.02	1.03
Greece	1.01	1.01	1.01
Guatemala	1.07	0.95	0.99
Honduras	1.08	0.98	1.03
Hungary	1.01	1.02	1.03
Iceland	1.03	0.99	0.99
India	1.03	0.96	0.97
Indonesia	1.04	0.95	0.97
Ireland	1.00	1.02	1.02
Israel	1.01	1.02	1.02
Italy	0.99	1.02	1.01
Jamaica	1.08	0.97	1.02
Japan	1.02	1.00	1.01

Table A-2. (Continued)

Country	Efficiency	Technical	Malmquist TFP Index
Malaysia	1.08	0.96	1.00
Malta	1.03	1.01	1.05
Mexico	1.05	0.97	1.01
Morocco	1.06	0.97	1.02
Netherlands	1.00	1.01	1.01
New Zealand	1.00	1.02	1.02
Nicaragua	1.11	0.97	1.03
Norway	1.22	0.99	1.01
Oman	1.00	1.00	1.00
Pakistan	1.03	0.97	0.98
Peru	1.06	0.97	1.02
Philippines	1.05	0.96	0.99
Poland	1.02	1.01	1.02
Portugal	1.02	0.99	1.01
Qatar	1.11	0.96	1.06
Republic of Korea	1.00	0.94	0.91
Saudi Arabia	1.04	0.94	0.93
Singapore	1.00	0.99	0.99
Spain	1.01	1.02	1.02
Sri Lanka	1.10	0.92	0.97
Sweden	1.00	1.02	1.01
Switzerland	1.00	1.01	1.01
Thailand	1.01	0.96	0.96
Trinidad and Tobago	1.08	0.99	1.05
Tunisia	1.05	0.97	1.01
Turkey	1.04	0.97	0.99
United Kingdom	0.99	1.02	1.01
United States	0.99	1.03	1.02
Venezuela	1.05	1.00	1.03
mean	1.04	0.99	1.01

Table A-3. Parameter Estimates for Dummy Variables of the Agricultural Output Equation: Fixed-Effects Model.

Country	Estimate	S.E.	T-Value	P-Value
Algeria	20.39	2.98	6.84	<.0001
Argentina	21.28	3.08	6.9	<.0001
Australia	20.41	3.16	6.46	<.0001
Austria	21.45	3.08	6.96	<.0001
Barbados	19.47	2.74	7.12	<.0001
Bolivia	19.52	2.68	7.29	<.0001
Brazil	20.2	2.83	7.14	<.0001
Canada	19.01	2.94	6.46	<.0001
Chile	18.68	2.67	6.99	<.0001
China	18.87	2.64	7.14	<.0001
ChinaHKSA	18.9	2.56	6.38	<.0001
Colombia	16.63	2.56	6.5	<.0001
Costa Rica	15.6	2.57	6.07	<.0001
Cyprus	14.21	2.63	5.4	<.0001
Denmark	14.59	2.72	5.36	<.0001
Ecuador	14.01	2.44	5.75	<.0001
Egypt	14.27	2.37	6.03	<.0001
El Salvador	12.92	2.27	5.7	<.0001
Ethiopia	12.52	2.19	5.72	<.0001
Finland	12.38	2.56	4.83	<.0001
France	13.43	2.57	5.22	<.0001
Germany	13.05	2.51	5.2	<.0001
Greece	12.29	2.35	5.24	<.0001
Guatemala	11.6	2.08	5.58	<.0001
Honduras	10.6	2.11	5.03	<.0001
Hungary	10.83	2.25	4.82	<.0001
Iceland	10.24	2.16	4.74	<.0001
India	10.99	2.12	5.19	<.0001
Indonesia	10.37	1.87	5.56	<.0001
Ireland	10.01	2.05	4.89	<.0001
Israel	9.6	1.95	4.93	<.0001
Italy	9.86	2.01	4.9	<.0001
Jamaica	8.4	1.66	5.08	<.0001
Japan	9.3	1.86	5	<.0001
Jordan	7.31	1.6	4.56	<.0001
Malaysia	7.51	1.55	4.85	<.0001

Table A-3. (Continued)

Country	Estimate	S.E.	T-Value	P-Value
Malta	6.04	1.44	4.2	<.0001
Mexico	6.33	1.48	4.27	<.0001
Morocco	5.2	1.34	3.88	<.0001
Netherlands	6.47	1.47	4.4	<.0001
New Zealand	5.76	1.49	3.87	0
Nicaragua	4.9	1.2	4.07	<.0001
Norway	4.98	1.41	3.54	0
Oman	4.21	0.96	4.39	<.0001
Pakistan	4.48	1.19	3.78	0
Peru	3.73	1.08	3.46	0
Philippines	3.49	1.03	3.4	0
Poland	3.08	1.29	2.38	0.02
Portugal	2.7	1.16	2.32	0.02
Qatar	1.7	0.92	1.84	0.07
Republic of Korea	3.12	0.71	4.41	<.0001
Saudi Arabia	1.08	0.48	2.27	0.02
Singapore	2.38	0.43	5.52	<.0001
Spain	2.61	0.55	4.72	<.0001
Sri Lanka	1.26	0.38	4.79	0.03
Sweden	1.39	0.5	2.77	0.01
Switzerland	1.82	0.43	4.24	<.0001
Thailand	1.51	0.26	5.79	<.0001
Trinidad and Tobago	0.43	0.18	2.38	0.02
Tunisia	0.32	0.11	2.85	0
Turkey	1.02	0.22	4.59	<.0001
United Kingdom	0.07	0.33	0.23	0.82
United States	1.21	0.36	3.36	0
Venezuela	12.3	2.46	5.38	<.0001

Table A-4. Parameter Estimates of Dummy Variables for the Agricultural Export Equation: Fixed-Effects Model.

Country	Estimate	S.E.	T-Value	P-Value
Algeria	-1.57	0.18	-8.85	<.0001
Argentina	1.65	0.15	10.87	<.0001
Australia	1.98	0.15	13.32	<.0001
Austria	0.79	0.2	3.99	<.0001
Barbados	2.76	0.62	4.45	<.0001
Bolivia	1.01	0.18	5.59	<.0001
Brazil	0.96	0.3	3.19	0
Canada	1.82	0.13	13.82	<.0001
Chile	1.83	0.15	12.25	<.0001
China	-0.54	0.58	-0.93	0.35
ChinaHKSA	-0.63	0.64	-0.96	0.84
Colombia	1.6	0.15	10.57	<.0001
Costa Rica	2.91	0.29	9.92	<.0001
Cyprus	2.34	0.48	4.83	<.0001
Denmark	3.06	0.26	11.97	<.0001
Ecuador	2.26	0.16	14.19	<.0001
Egypt	-0.41	0.2	-2.06	0.04
El Salvador	2.22	0.22	9.95	<.0001
Ethiopia	0.99	0.26	3.84	0
Finland	1.39	0.23	6.03	<.0001
France	1.66	0.18	9.36	<.0001
Germany	1.36	0.19	7.05	<.0001
Greece	1.47	0.16	9.46	<.0001
Guatemala	2.26	0.16	14.13	<.0001
Honduras	2.82	0.23	12.13	<.0001
Hungary	1.79	0.15	11.59	<.0001
Iceland	4.77	0.65	7.39	<.0001
India	-0.65	0.54	-1.2	0.23
Indonesia	0.3	0.33	0.89	0.38
Ireland	3.04	0.29	10.29	<.0001
Israel	1.84	0.25	7.31	<.0001
Italy	0.98	0.17	5.74	<.0001
Jamaica	2.17	0.31	7.08	<.0001
Japan	-0.56	0.24	-2.29	0.02
Jordan	1.9	0.28	6.68	<.0001
Malaysia	1.2	0.12	9.81	<.0001

Table A-4. (Continued)

Country	Estimate	S.E.	T-Value	P-Value
Malta	1.93	0.58	3.33	0
Mexico	0.74	0.22	3.38	0
Morocco	1.45	0.12	11.63	<.0001
Netherlands	2.81	0.17	16.7	<.0001
New Zealand	2.75	0.29	9.46	<.0001
Nicaragua	2.23	0.25	8.89	<.0001
Norway	2.63	0.28	9.37	<.0001
Oman	1.56	0.37	4.21	<.0001
Pakistan	-0.03	0.29	-0.11	0.91
Peru	1.39	0.13	11.06	<.0001
Philippines	0.76	0.21	3.69	0
Poland	0.81	0.15	5.45	<.0001
Portugal	0.91	0.15	6.03	<.0001
Qatar	0.52	0.52	0.99	0.32
Republic of Korea	0.94	0.15	6.46	<.0001
Saudi Arabia	-0.01	0.17	-0.05	0.96
Singapore	3.29	0.43	7.6	<.0001
Spain	1.31	0.15	8.5	<.0001
Sri Lanka	-0.86	0.84	-1.21	0.34
Sweden	1.31	0.18	7.4	<.0001
Switzerland	1.56	0.21	7.42	<.0001
Thailand	1.77	0.19	9.54	<.0001
Trinidad and Tobago	2.06	0.43	4.8	<.0001
Tunisia	0.82	0.16	5.28	<.0001
Turkey	0.88	0.19	4.5	<.0001
United Kingdom	1.11	0.16	6.87	<.0001
United States	0.54	0.34	1.6	0.11
Venezuela	5.23	1.45	7.23	<.0001